Agriculture
for High Schools

ANDREWS

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By

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PREFACE

Since *Agriculture for High Schools* was first published in 1927 many advances have been made in the field of agriculture. It has never been more evident than it is today how skilled in many respects a successful farmer must be. The modern farmer and the scientist now go hand in hand. The battle against drought, plant and animal diseases, insect pests, and other factors that reduce farm profits has not been won, but almost daily new and more effective methods of attack are being made available by the agricultural scientist for use in a practical way on the farm.

Agriculture is an exceedingly important industry in many parts of Canada. In the West particularly, the welfare of all the people is vitally linked with the prosperity of the farmer. With this thought in mind, the author has treated the subject from a general rather than a strictly vocational point of view, while at the same time making every effort to discuss the problems and operations of the farm in as practical and helpful a manner as possible. Stress has been placed on the principles underlying a permanent system of agriculture, and it is hoped that the student who intends to engage in agricultural activities will find many suggestions of practical value to him. A serious attempt has been made, as well, to catch the interest of other students, and to acquaint them with the fundamentals of this basic industry. The student who is familiar, even to a slight degree, with the problems and difficulties confronting the farmer will be better equipped to take his place in whatever sphere of activity he may in the future find himself, particularly in Western Canada, an essentially agricultural community.

For assistance in the preparation of the original and the revised text sincere thanks are extended to Mr. G. B. Walker, Professor V. W. Jackson, Dr. G. B. Stillwell, Mr. C. A. Edwards, Mr.

A. J. Clark, Mr. A. Hodgkins, Mr. T. W. Hunt, Mr. A. R. Brown, Mr. W. H. Boyle, Mr. S. Einarsson, Mr. O. D. Davidson, Mr. M. P. Tullis, Mr. P. E. Reed, and to Mr. W. Langford Oddie, Agricultural Representative, Assiniboia, Saskatchewan, for whose co-operation in this 1949 revision the author is particularly grateful. The author is also greatly indebted to Professor W. M. Drummond, of the Ontario College of Agriculture, Guelph, Ontario, for reading the manuscript and for offering many valuable suggestions.

Each time that *Agriculture for High Schools* is reprinted, every effort will be made to see that up-to-date information replaces any that has become obsolete.

Free use has been made of the information available in various government publications. The author acknowledges the assistance received from these sources.

The value and attractiveness of the book have been greatly enhanced by the use of many illustrations lent by the Saskatchewan and the Dominion Departments of Agriculture, and by other organizations and individuals. The author desires to express his great appreciation to all who have so generously supplied illustrations, which are acknowledged as they appear in the text. The illustrations of poultry on pages 318, 319, and 321 are reproduced through the courtesy of *Poultry Tribune*, Mt. Morris, Illinois, U.S.A.

H. C. A.

TO THE TEACHER

This book has been written as a combination text and manual. Problems and experiments have been used to elaborate topics or to emphasize points already discussed. The teacher should keep this in mind at all times and should consider no part of the book completely covered until all exercises have been performed and thoroughly studied in relation to the topic to which they refer. A number of projects have been outlined, and others will suggest themselves. Several of these should be selected each term for the students to perform with the consent and co-operation of their parents. All work in agriculture should be arranged so that those parts which are seasonable may be taken up at the appropriate time.

Students should be encouraged to make accurate and detailed observations and to record their observations, neatly and concisely, in suitable note-books. Simple descriptive diagrams will be found to be valuable teaching aids whenever a topic can be illustrated. The students' written reports of all but a few of the simplest experiments should be accompanied, where appropriate, by a cross-sectional diagram of the apparatus, drawn in more than one colour, with all parts named, and with the result of the experiment shown if possible. Good-sized, simple, outline drawings, without shading, are best.

The success of teaching depends, after all, upon the teacher. Every effort should be made to relate the work of the school to the everyday life of the student. In a text on general agriculture, it is not possible to deal with all of the facts of the subject—only a few of the fundamentals can be outlined. The teacher must be responsible for discussions of local practices, and to this end he should learn the varieties of grain, breeds of live stock, methods of tillage, etc., which predominate in and are most

suitable for the district around his school. In the present revision (1949) much information has been added, some of it for reference and general reading. The teacher should carefully select those parts which best meet the needs and interests of the students. *The objectives set forth on page v should be kept in mind at all times.* The outline in the *Programme of Studies* prescribed by each Department of Education should be the teacher's guide in the organization of the lessons. It is also essential that both teacher and student should carefully watch newspapers and magazines for announcements referring to the advancement of agriculture.

Valuable reference material may be secured, largely without cost, from the following:

The various provincial Departments of Agriculture will furnish schools in their own provinces with bulletins and other helpful materials, usually without charge.

The Extension Department of the provincial university or agricultural college is also a source of useful publications.

The Publicity and Extension Branch, Department of Agriculture, Ottawa, will supply, without cost, many very useful bulletins, charts, etc. Each school should have a copy of the current *List of Publications.* Letters of application in this case require no postage.

From these sources, bulletins and pamphlets can be secured that deal with the topics discussed in this book and with other phases of agriculture that may be of special interest to some of the students. The school library should contain at least one copy each of these bulletins, and the students should be encouraged to use them. It is recommended that bulletins, etc., obtained from the foregoing departments, be used for reference purposes only—they are too costly to serve only as the source of one or two illustrations for a scrap-book or similar project.

Be very sure, also, to contact your local agricultural representative. The "ag. rep." can assist your students in many ways.

CHAPTER 1

THE SOIL

"The soil is not only the foundation of agriculture, but it is also the basis of all human prosperity. It is the most common and yet the most precious thing in all the world."—Harris and Stewart.

Man's conquest of the soil has done much to prepare the way for his advancement in other respects. The productiveness of the soil has been increased immeasurably with resulting benefit to mankind.

Soil is usually defined as the mixture of fine, loose, rock material and vegetable matter which covers the solid part of the earth and in which plants find a foothold and certain food materials. The depth of soil covering the bed-rock varies from a few inches to many feet. In some places there is no soil, and the rocks are entirely bare.

The scientific method. In this chapter you will find many facts about the soil, but it is not possible to include in a single chapter of any book, all that is known about the soil. Nor is it possible to keep any book on this subject completely up-to-date with all the new discoveries that are being made from time to time.

You should, therefore:

1. Read other authoritative publications.
2. Ask questions of informed people.
3. Observe and experiment.
4. Keep an open mind; that is, be ready to accept new ideas when there is good evidence that they are right.
5. Avoid jumping to conclusions; that is, refrain from making decisions until you have checked your ideas to be sure that they are based on fact.

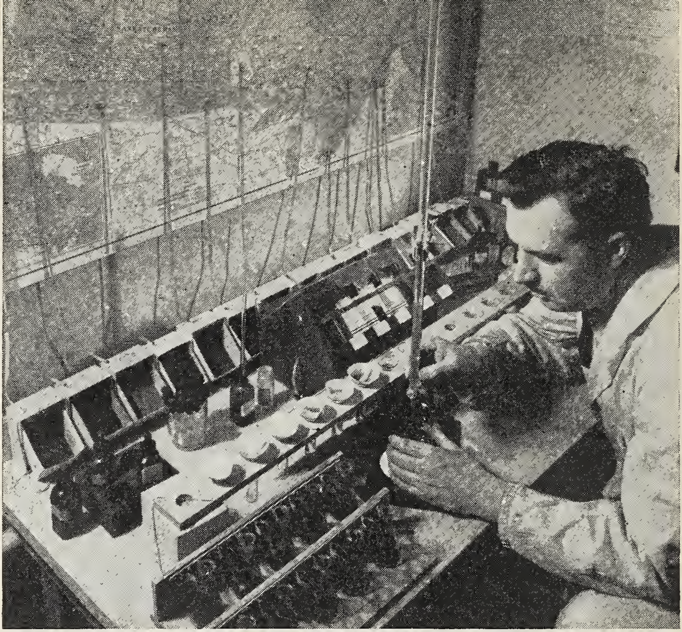


Fig. 1. Soil testing services give farmers scientific knowledge of the condition of their soil. (Photo from Canadian Industries Limited)

These are the methods and the attitudes that have enabled scientists to discover the facts that are known about the soil. You should adopt their way of working and thinking as you proceed in your study of agriculture.

Man's knowledge of the soil and its management is far from complete. You should, therefore, be constantly on the alert for new discoveries and developments.

Origin and formation of soils. Soils have been formed by the weathering or crumbling of the solid rock that originally covered the surface of the earth. For many centuries various agents have been at work reducing the rock to fine particles.

Water, by dissolving, eroding, and many other methods of attacking rocks, is one of the chief agents in this great process. Swiftly flowing water, partly because of the action of the material it carries with it, is a major factor in soil formation. Rivers have always played an important part in making and transporting

Fig. 2. Water-worn rocks on the Petawawa River, Ontario. What other factors will be operating to reduce these rocks to soil? (Photo from Canadian Government Motion Picture Bureau)

soil, widening and deepening their beds, and building up new areas of land at lower levels. Contraction and expansion of rocks, as a result of changes in temperature over long periods, finally breaks them apart. Carbon dioxide from the air unites with water to form an acid that attacks rocks. Wind and frost also are important agents. Glaciers formerly covered vast areas in North America, and by their weight and motion did much to pulverize the rocks of these regions and transport to new locations the soil material thus formed. The roots of plants pry rocks apart and secrete an acid that causes their decomposition. Decayed plant material, too, forms an important soil constituent. Burrowing animals also assist in the great work of reducing rocks to soil particles.

There are many kinds of soil, and each has been formed in a different manner and from different kinds of rocks. Some soils, known as *sedentary* or *residual* soils, have remained where they were first formed. Others have been transported long distances from the places where they originated. Most of the

soils in Western Canada have been transported to their present locations. Some are *alluvial* or water-formed, and others have been formed and carried from other parts of the country by glacial action.

Project

Make a study of the soil and rock formation of your district. How do you account for the muddy appearance of most of our rivers?

Surface soil and sub-soil. The *surface soil* is the top layer, usually five or six inches deep, which is cultivated and in which seeds are planted. The *sub-soil* is the layer below the top soil, and may vary from two or three to many feet in depth depending on the locality.

Exercises

1. Examine the walls of an excavation or the cut bank of a road. Observe the difference between the surface soil and the sub-soil in fineness, colour, number of roots, etc. Is the line between the two soils distinct?
2. Which soil is more exposed to weathering influences?
3. Which will contain the most organic matter? Give reasons for your answer.
4. Ask farmers about the nature of the sub-soil in your locality.

Over ninety per cent of the feeding roots of plants are found within the upper parts of the soil; consequently, the surface soil contains more decayed plant and animal matter and is darker in colour than the soil below. For the same reason, it is usually better aerated and has greater water-holding capacity. It is also finer in texture and, in general, more productive. In some parts of Canada a very black top soil is found above a sub-soil that is almost white; in other parts these differences between the surface and the sub-soil are less clearly defined.

Importance of the sub-soil in crop production. In selecting soil in which to grow crops it is important to examine the sub-soil carefully. An impervious sub-soil will result in poor drainage. A sub-soil that is loose and coarse, on the other hand, will allow

moisture to escape too readily. Either of these types or a subsoil that is very low in available plant food, limits the productive region of the soil to the top few inches and is unsatisfactory for agricultural purposes.

Composition of soil. There are two ways of classifying the composition of soil: according to the substances from which the soil is formed; and according to the size of the soil particles.

(*a*) *Chemical composition* refers to the substances from which soils are formed.

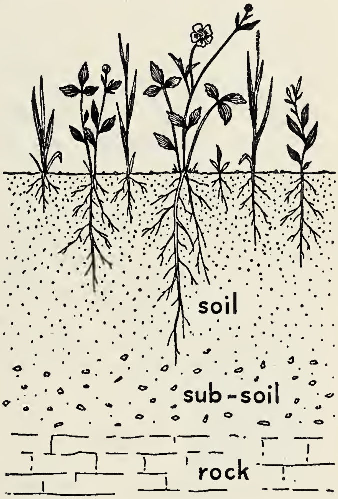


FIG. 3. Soil, sub-soil, and bed-rock.

Exercises

1. Remove a sample of ordinary soil from field or garden. Allow it to become thoroughly dry. Place it in a crucible and weigh it. Heat it intensely (two or three hours) until all the dark colour is removed, and then weigh it again. The difference in weight is the amount of organic matter in the soil.

2. Thoroughly mix a sample and place it in an evaporating dish. Moisten and stir it to form a thick paste. Using clean forceps, carefully lay strips of red and blue litmus paper over the surface and gently press them into close contact with the soil. If the blue litmus paper turns red, it indicates the presence of an acid. If the red litmus paper turns blue, it indicates the presence of an alkali. There are few acid soils in Saskatchewan. In some other provinces, however, an acid condition is quite common, although the situation varies greatly between localities and sometimes even in the same locality.

3. Place about an inch and a half of common soil in an ordinary sized test-tube. Fill the test-tube three-quarters full of distilled or rain water. Boil it vigorously for five or ten minutes. It may be necessary to stir the soil with a wire or glass rod several times

until the water starts to boil. After boiling, allow the soil material to settle; then pour off the liquid. Add a small amount of nitric acid to the liquid, and cool it. A yellow colour indicates the presence of organic nitrogen.

4. The tests for inorganic nitrogen and for the other essential plant food elements may be found in any chemistry text but are not recommended for junior students.

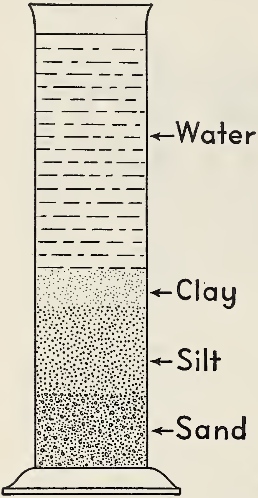


Fig. 4. An experiment to learn the composition of soil.

5. Place a small quantity of soil in a flask. Insert into the mouth of the flask a two-holed rubber stopper in which a thistle-tube and a bent glass delivery-tube have been previously placed. Pour in enough water to cover the soil and the end of the thistle-tube. Attach a rubber tube to the glass delivery-tube. Pour a small amount of hydrochloric acid down the thistle-tube, and, when gas begins to come from the soil, pass it through lime-water by means of the rubber tube. If the lime-water turns milky, it indicates that carbon dioxide has been liberated from the soil by the acid. This proves that the soil contains a carbonate salt.

(*b*) *Physical composition* refers to the size of soil particles.

Exercises

1. Place about three inches of sandy soil in a 200 c.c. graduate jar or other tall, slender glass vessel. Fill the vessel with water. Hold the hand over the open end and shake the jar vigorously until all lumps in the soil are thoroughly broken up. Then set it on a table and allow it to settle. Examine it in a few minutes and mark the height of the settled particles. Do the same an hour later and also after several hours. It should now be noticed that the soil has been separated into three parts. The coarser particles, which settled to the bottom in a few minutes, are sand. The finer particles, which settled in an hour, are silt. The very fine grains, which remained in suspension in the water several hours, are clay.

2. Make a drawing of the above experiment, and label the different soil separates.

In making the foregoing tests the class might be divided into several groups. Each group should collect and test samples of soil from various parts of the district. Afterwards the class should assemble with the teacher to compare and summarize results. Make tests of sub-soils as well.

The first of the foregoing experiments demonstrates that, although soil is composed to a large extent of fine rock material, it is not all mineral or inorganic matter. The part of the soil that burns is called *humus* or organic matter. Humus is composed of decayed vegetable or animal material. If you examine the soil closely, you will find bits of roots, leaves, and stems. These, when decayed, form humus. Humus is dark in colour, and it has been found that it absorbs heat rapidly and is an important factor in improving the water-holding capacity of the soil. It also is the source of nitrogen and, in all probability, a large part of the other food elements that plants secure from the soil. Humus is also an important factor in encouraging the activity of useful soil bacteria. A soil with little or no humus is useless for the production of crops. The plant fibre helps to prevent the soil from drifting or blowing, because it binds the particles of soil together. In parts of the country where artificial fertilizer is used extensively, the need for humus to hold the fertilizer and prevent it from being wasted has been clearly seen. Later we shall consider methods of maintaining a good supply of humus in the soil.

Exercise 1 on page 6 demonstrates that there are coarse and fine particles or grains in the soil. The particles are classified according to size as follows:

Fine Gravel	2— 1 millimetres.
Coarse Sand	1— .5 millimetres.
Medium Sand	.5— .25 millimetres.
Fine Sand	.25— .10 millimetres.
Very Fine Sand	.10— .05 millimetres.
Silt	.05—.005 millimetres.
Clay	Smaller than .005 millimetres.

The sand, silt, and clay contain potassium, phosphorus, iron, sulphur, calcium, etc. Sand, which is formed largely from a mineral called quartz, is glassy in appearance, heats and cools quickly, and makes the soil loose and open. Clay is formed chiefly from a mineral called feldspar and, because it is much finer than sand, causes a soil to become sticky in wet weather or hard and baked in dry weather. Clay heats and cools slowly. It also possesses high water-holding capacity. The tiny clay particles represent the last stage in the break-down of larger rock particles. They contain minerals which are gradually released to nourish growing plants.

Exercises

1. Weigh equal volumes of dry sand, clay, and humus (leaf mould). Compare their weights.
2. Moisten and make a ball of sand and a ball of clay. When they have become thoroughly dry, compare the looseness of the two samples.
3. On a warm day expose to the sun some sand and some clay. After a time, thrust the bulb of a thermometer just below the surface of each sample, and compare the temperatures.
4. In funnels lined with filter papers, place equal amounts of dry pulverized sand, clay, and a soil containing a percentage of humus. Insert the stems of the funnels into equal sized test-tubes. Pour three-quarters of a test-tube of water through each sample. Observe the amount of water in the test-tube below the funnels. Which sample has retained the most moisture? Draw a diagram to show clearly the result of this experiment. Account for the water-holding capacity of sand, clay, and soils rich in humus. The apparatus shown at the top of page 9 may be substituted for that outlined in this exercise.

Soil texture and structure. The term *texture* refers to the size of the soil particles. If the particles are large, as in sandy soils, the soil is said to have a coarse texture; if the particles are very small, the soil is said to have a fine texture. Clay soils are fine in texture. Does texture influence the water-holding power of a soil, the amount of air in it, or the ease with which it may be ploughed?

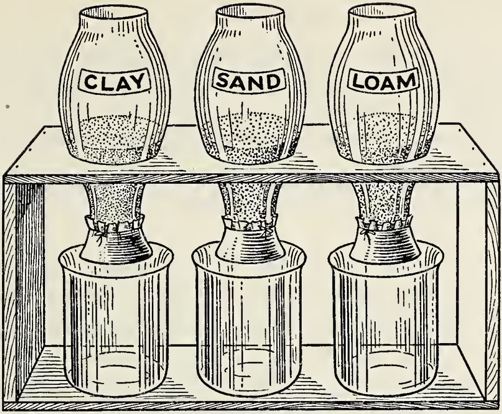


FIG. 5. If an equal amount of water is poured into each lamp chimney, which of the three soil materials (clay, sand, or a soil very rich in humus) will allow the least water to run through? Which will allow the most water to run through?

Exercise

Spread several samples of soil thinly on a piece of paper. Observe whether the particles are separated or in groups.

The arrangement of the soil particles in groups is known as the *structure* of the soil. It will be seen from the foregoing exercise that in most soils the particles are bound together in groups or *granules.* When the structure of the soil is fine and loose, so that it is in the best condition for planting seeds, the soil is said to be *friable* and in *good tilth.* Soil in poor tilth is either lumpy or too fine.

Porosity or pore space. Since the particles do not lie close together, the soil of which they are a part must contain a great deal of space. It has been found that under ordinary field conditions, from forty to sixty per cent of the total volume of the soil is space. This pore space is important, as it determines the amount of water or air that may enter a soil.

Exercises

1. Place in beakers equal volumes of sand and clay. Pour water on the samples, keeping an accurate record of the amount of water

that each will absorb. Where does the water go, as it soaks into the sand and clay? What does this experiment indicate about the porosity of sand and clay?

2. What influence will texture and structure have upon the amount of pore space in a soil?

3. Sandy soils are more porous than clay soils but have less total pore space. Explain.

Soil air. Place a small dish of soil quickly under water. Observe the air bubbles that rise out of the soil. Air in the soil is essential to plant life since oxygen is necessary for the germination of seeds, the growth of roots, and the functioning of beneficial bacteria. By cultivating the soil, we break up and loosen it and allow the air to enter. Thus impurities in the soil are oxidized and changed into harmless substances, the formation of injurious acids is prevented, and the soil is maintained in a sweet, growth-promoting condition. Too much air, however, is likely to dry out the soil. The amount of cultivation required depends upon the type of soil. Sandy soils are apt to contain too much air, while it is often difficult to maintain the proper amount of air in soils of a clay nature.

Soil temperature. Seeds germinate best at a temperature between 35° and 70° Fahrenheit. The soil should be managed so that it heats to this temperature early in the spring in order to germinate the crops as soon as possible. Damp, poorly drained soils are cold. Well tilled soils are warm. Dark-coloured soil usually heats quickly and remains warm. Why? How do sandy and clay soils compare in temperature? The heat in the soil is received chiefly from the sun or warm rains. Some heat is produced in the soil by such chemical action as the decay of plants.

Colour. The colour of the soil depends upon the ingredients which compose it. If soils are chiefly sand or clay, they are light in colour. If they contain a good supply of humus or organic matter, they are dark. It is not difficult to see, then, that we could safely judge a light-coloured soil to be lacking in rich-

ness. Besides containing more food for plants, dark-coloured soils hold water better and warm up more quickly than light-coloured soils, and are, therefore, better for producing crops.

Soil moisture. Moisture is essential in many life processes of the plant. It is the first limiting factor in crop production, because the plant cannot absorb food from the soil until that food is dissolved in water.

Exercise

Drop a handful of fresh soil into a glass of distilled water. Stir it well, then filter the water into an evaporating dish. Evaporate it to dryness. In the bottom of the dish you will find a dark precipitate. What is your conclusion?

The best soils are useless without moisture. Practically all of the enormous quantity of moisture required by the plant is secured from the soil, which must act as a storehouse for water and supply it to the plant when it is most needed.

Problem

Estimate the inches of rainfall required to produce twenty bushels of wheat. An inch of water spread over an acre weighs 100 tons. In the case of wheat, 700 pounds of water are required to produce one pound of dry matter. The kernels and straw, when ripe, will be about eighty-five per cent dry matter, and one-half of the dry matter will be stems and leaves (straw). A bushel of wheat weighs sixty pounds. Think over the facts given in this problem. Much more rain than is actually required must fall, because loss is caused by run-off, seepage, evaporation, and weeds.

Rainfall. In most parts of Canada the chief sources of soil moisture are rain and snow. If the rainfall fails, there is no crop. The average annual precipitation in Western Canada is from thirteen to twenty inches, of which fifty per cent falls during May, June, July, and August. In Eastern Canada, the annual precipitation is from thirty to forty inches. What is the average rainfall in your district?

Kinds of moisture. There are three kinds of soil moisture—gravitational, capillary, and hygroscopic.

After a heavy rainfall, when the soil has become saturated, a part of the water soaks rapidly down through the soil or runs off over the surface. Because this moisture is not held by the soil, but responds readily to the pull of gravity, it is called *gravitational* or *free moisture.* It is not used by plants but is often injurious to them, as it fills up the pore spaces of the soil and drives out the air. If we dig down into the soil, we can usually come to free water, as we do in sinking a well. The level at which this free water is found is known as the *water table,* and may be but a few inches or many hundreds of feet below the surface. In most parts of the Prairie Provinces gravitational moisture from the surface is soon used up in moistening the upper layers of the soil.

As the free moisture finds its way down through the soil, films of moisture are left around each soil particle. This film water is known as *capillary moisture.* As the roots of plants come in contact with this water, they absorb it. Capillary or film moisture is, therefore, the available or useable soil moisture. It moves in all directions through the soil in the same manner as ink soaks into a blotter. When the roots of plants have used up all the water immediately around them, moisture from damper parts of the soil moves by capillary action to the dry sections. Capillary moisture does not fill up the spaces between the soil particles. It is, therefore, possible to have a liberal supply of both capillary moisture and air in the soil at the same time. It was formerly thought that water moved upward through the soil by capillary action. But it has been demonstrated that the upward movement is so extremely slow that it may be considered to be negligible and of no value in crop production.

It is obvious that, to maintain a good supply of moisture, well distributed throughout the soil and in the most available form, the soil must be maintained in a state of good tilth. Capillary movements of moisture in the soil depend upon the size and the compactness of the soil particles. The presence of sand decreases the ability of the soil to hold moisture. Clay increases the water-

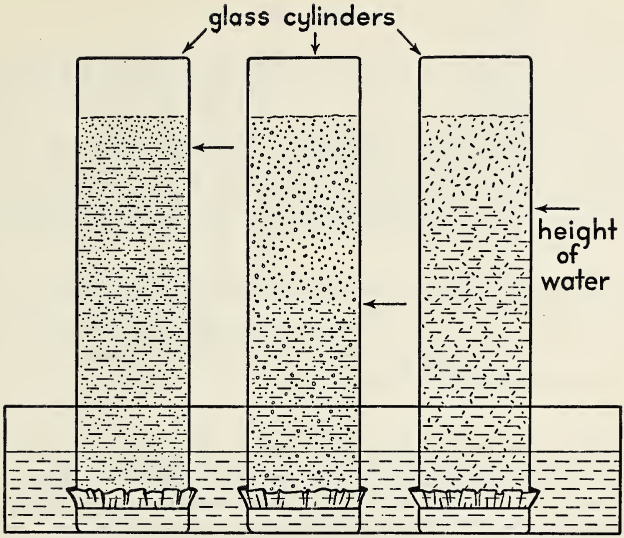


FIG. 6. An experiment to determine the rise of capillary moisture through different kinds of soil. Identify each type of soil represented above.

holding capacity. Humus has a good effect upon the moisture content of soils, as it opens up clay soils to permit better drainage, and acts as a sponge in sandy soils to hold moisture in the soil.

Exercises

1. Take several lamp chimneys (deeper glass cylinders are better if available). Tie a piece of cheese-cloth over the bottom of each. Fill one with dry sandy soil, another with dry clay soil, and so on. Each soil should be well pulverized. Place the chimneys in a vessel of water, and observe in which soil the water rises most quickly. Make observations for several days. The water should rise most quickly through sand, less quickly in soils rich in humus, and most slowly but to the highest level in clay. Draw a descriptive diagram of this experiment. Label each kind of soil. Mark in each case the height to which the water rose. Explain each result.

2. Fill a tumbler with very small marbles or shot. Notice the spaces between. Fill the glass with water. Pour the water off. Notice the film around each marble and where the marbles are in

contact. The water that ran off through the marbles is gravitational moisture, and the moisture that collected around the marbles is capillary moisture.

3. Does the foregoing discussion of capillary moisture help you to explain why the clay retained more water than the sand in Exercise 4, page 8? Take into consideration the fact that, although they are smaller, the particles of clay have a greater total surface area than the sand particles.

Hygroscopic moisture is the water found in soils that have been thoroughly air-dried. Only intense heat will separate it from the soil particles, so it is not difficult to see that this form of moisture is not available to the plant.

Exercise

Weigh accurately a small quantity of thoroughly air-dried soil; heat it in an oven at about 200°F. until its weight is constant. Do the same with dry road-dust. The loss of weight in each case represents the amount of hygroscopic moisture in the sample of soil.

The loss of soil moisture and how to prevent it. Not all of the annual precipitation becomes available to crops. However, much can be done to hold it in the soil until crops can make use of it. The method most commonly used is known as *summer-fallowing.* This means that the soil is cultivated periodically throughout the summer in order to kill the weeds and prevent evaporation. By this means approximately one-half of the yearly precipitation can be held in the soil to be used by the crop that is to follow, provided the right practices are carried out during the fallow period.

A great deal of moisture is lost because it runs off over the surface of the ground. This loss may be partially prevented by cultivating the land in such a manner that the water is held until it soaks in. One such way is to cultivate across the slope wherever this is practical. A liberal amount of humus or organic matter such as plant trash in the soil not only opens the soil up and allows the water to enter, but also absorbs a considerable quantity of water itself. Leaving the stubble standing during

the winter to trap snow may result in the addition of some moisture to the soil, but usually the snow has disappeared before the ground has thawed sufficiently to allow the entrance of water. It is now considered that under ordinary conditions winter snow adds very little moisture to the soil. This, however, is probably more true of Western than of Eastern Canada.

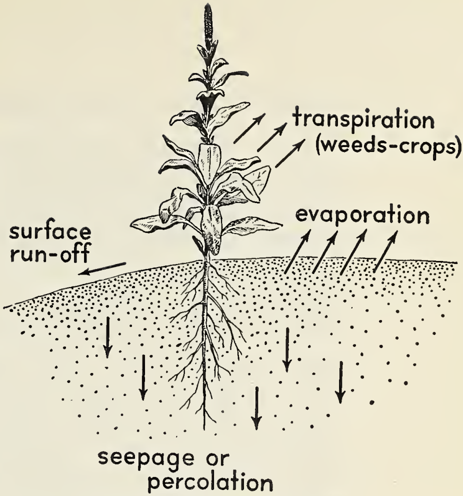


FIG. 7. The loss of moisture from the soil. Which of the four losses illustrated is considered to be of chief importance in farming?

The more porous soils, such as coarse sandy soils, allow the moisture to soak through them beyond the reach of the roots of plants. This may be partially checked by adding humus or organic matter in the form of barnyard manure to supplement the stubble that is present in the soil. The humus acts as a sponge and holds large quantities of moisture.

Formerly it was thought that much soil moisture was lost by evaporation. To prevent this loss the soil was cultivated to form a layer or *mulch,* two or three inches deep, of loose, dry soil on the surface. But, while it is true that a substantial part of the rainfall is quickly lost after each shower, it has been established that, once moisture penetrates the soil to a depth of four or five inches, or to the depth of the furrow slice if it is beyond the maximum depth for evaporation, it is not lost by evaporation. The practice of keeping a dust mulch on the surface of the soil has, therefore, been discredited. During rainless weather, the soil is already dry to a depth of three or four inches, which condition prevents evaporation of moisture from below. The minimum amount of cultivation necessary to control weeds is considered to be quite sufficient for conserving moisture.

Weeds, like all other plants, use an enormous amount of water. Since they serve no good purpose, the water which they absorb is wasted. Even a slight infestation of weeds will seriously reduce soil moisture. Fields should be kept free of weeds to prevent this heavy loss.

When crops are sown too thickly, more plants are produced than the supply of moisture will maintain. The surplus plants waste valuable water. Crops should be sown at a rate that will ensure a sufficient supply of moisture for each plant. Even under normal conditions, a crop of wheat may by harvest time have completely exhausted the available moisture in the soil to a depth of five or six feet. (See Figure 13.)

Ploughing loosens the soil and very often leaves it lumpy, so that it dries out quickly. To prevent this, the soil should be harrowed immediately after it is ploughed. What is the danger of making excessive use of the drag harrow?

Farmers could learn a great deal about the effectiveness of their cultural practices and the chances of a crop by determining the depth of moist soil in their fields in the fall and at seeding time. For example, in the case of loams and clays, moist soil to a depth of three feet or more constitutes a good reserve, two feet is fair, and eighteen inches or less indicates a supply of moisture so low that it must be supplemented by more than normal rainfall to produce an average crop.

IMPORTANT.—Students and teachers should consider co-operatively what they wish to achieve in a course in agriculture. Read and discuss pages v, vii, 1, 24, and 174.

Exercises

1. Gather samples of soil from the first three inches, the second three inches, and the third three inches of soil in a field, and also a sample from the middle of a road which has been packed hard. Weigh each sample. Dry out the moisture. Weigh again. Decide which sample contains the most moisture. Give reasons.
2. Ask farmers about the danger of too fine a mulch.
3. Discuss this statement: "Weeds are the main controllable cause of loss of moisture from the soil."

Dry land farming. In localities where the annual precipitation is less than twenty inches, as, for example, the open plains of the prairies, special methods of soil cultivation are necessary to ensure profitable crops. The methods followed are known as *dry land farming.* Several methods employed in dry land farming have been discussed in the foregoing paragraphs. The summerfallow and other methods will be dealt with more fully in later sections of the book.

Types of soil. Types of soil are determined chiefly by the percentage of sand, silt, clay, and humus found in them.

Sandy soils contain a large amount of sand, very little clay, and usually only a small supply of humus. In weight they average about 110 pounds per cubic foot. They are coarse in texture, and the particles lie loosely together. Such soils do not hold water very well and are inclined to be too dry to raise good crops. As they contain such a small amount of humus, their fertility is soon exhausted.

Clay soils contain very little sand or humus; they are composed largely of clay. In actual weight they are lighter than the sandy soils, a cubic foot weighing on the average approximately eighty pounds. But clay soils are called heavy because they are sticky and difficult to work. Can you tell why? They have great water-holding power, but in the spring they are frequently very slow in becoming dry and warm enough for planting. After a heavy rain, a clay soil bakes on top and forms a thick, hard crust.

Loam soils are composed of various amounts of sand and clay, and large quantities of humus. Such soils are usually productive and are considered the best for most crops. Loam soils are dark in colour, moderately easy to work, and, if cultivated properly, will be found to hold just about the right amount of moisture for plant growth.

There are many variations of the above three classes of soils, such as sandy loam, silt loam, clay loam, etc. In Saskatchewan, for example, the soils have been classified as follows: (1) brown soils of the short grass prairie and western section of the mixed

Fig. 8. Removing soil to study its composition, Dominion Experimental Farm, Ottawa. Notice the layers of soil. (Photo from Canadian Government Motion Picture Bureau)

prairie region; (2) dark brown soils in the eastern and more humid section of the mixed prairie region; (3) black soils of the parkland prairie region; (4) gray soils in the wooded areas of the more northerly stretches of the agricultural part of the province. In Ontario, on the other hand, the classification would be quite different. In the southern part of Ontario the soils are, generally speaking, of the gray-brown podzolic type. In the more northern regions of the province the podzolic type of soil tends to prevail. (*Podzolic* comes from a Russian word meaning ash-like.)

Note.—Students in each province should write to the Extension Department of the provincial university or agricultural college for further information about types of soil and major soil zones in the province and in the student's own locality.

Humus soils, or peat soils as they are more commonly called, are composed chiefly of decayed or partially decayed vegetable matter. They are found in the bottom of swamps and marshes where vegetation has been heavy. Peat soils are usually very light and are not of much value for the production of crops.

Heavy clay soils are a combination of clay and other materials. They are very fine and sticky, and consequently difficult to manage. Lack of humus or organic material increases the difficulty of tilling these soils. This may be overcome by adding organic matter such as barnyard manure. Lime may also be used, but it is much too expensive for application on a large acreage.

Either of these treatments causes the soil particles to cling together in small groups or granules. When properly managed, however, these soils produce good yields of wheat and other crops.

Alkali soils are soils that contain an excessive amount of several soluble salts. These soils are more fully dealt with on page 44.

Exercises

1. Which types of soil are actually heaviest? Explain why certain types of soil are commonly called heavy.

2. Prepare four samples of clay soil. To one add a supply of humus; to another a quantity of lime. Mix thoroughly. Now wet and pack into a ball all four samples. (*a*) Leave one pure clay sample and the two samples containing lime and humus at ordinary temperatures until thoroughly dry. Compare them as to hardness and friability. What treatment could you suggest for clay soils to prevent baking? (*b*) Freeze the second pure clay sample, then thaw and dry it. Is it now friable or hard? When should clay soils be ploughed to secure the most friable seed-bed?

3. Make a collection of the kinds of soil found in your district.

4. Summarize in tabular form your information about types of soil, paying particular attention to the soils of your own locality.

Elements required by plants. Ten elements are considered essential to plant life. Seven of these—nitrogen, phosphorus, potassium, calcium, iron, sulphur, and magnesium—are found in the soil itself. Water is the source of hydrogen and oxygen, and carbon is obtained from the air and the soil. The source of the elements and the form in which they are gathered by the plants are shown in the table on the next page.

It is now known that boron, copper, manganese, and zinc in "trace" amounts are also essential. They are called *trace elements* because very small amounts or mere traces are required.

With the exception of nitrogen, phosphorus, and potassium, the supply of plant food elements found in the soil is sufficient to last a great many years. The three exceptions, because of the necessity of replacing them at frequent intervals, become the controlling factors in soil fertility. In the soils of Western Canada, nitrogen and phosphorus are the two elements that are

Elements	Source	Form
hydrogen	soil	water
oxygen	air soil	carbon dioxide nitrates, carbonates, etc.
carbon	air soil	carbon dioxide carbonates
nitrogen	air soil	made available by nitrogen-fixing bacteria (*a*) on roots of legumes and (*b*) in most surface soils from organic materials
magnesium potassium calcium iron	soil	soluble salts of the metals, particularly the nitrates, sulphates, and carbonates
sulphur	soil	sulphates
phosphorus	soil	phosphates

likely to be lacking. In Eastern Canada the lack of all these elements varies widely from region to region.

Plants drink their food from the earth. For this reason the plant food materials in the soil are available to crops only when they are in a form that is soluble in water. It is, therefore, not the total supply of essential elements in the soil that influences crop yields, but rather the amount present in soluble form.

Nitrogen is found chiefly in the humus. It is essential for protein formation and growth, and is used in large quantities by all plants until flowering time. The leaves are a darker green, and the seeds develop better when an abundance of nitrogen is available. Lack of nitrogen retards growth, and makes leaves pale in colour. Too much results in excessive leaf growth and

inferior crop products. Nitrogen is probably the most important element as far as crop production is concerned, although this depends somewhat on the nature of the crop.

Phosphorus is necessary for cell formation and protein building. Seeds will not form without it. Flower, seed, and fruit production are encouraged when phosphorus is available.

Potassium performs a peculiar function in starch formation. No starch is formed if, for any reason, potassium is not available to the plant. Potassium promotes growth of root and stem, and increases resistance to disease.

Calcium is valuable not only because it is a plant food but because it produces a good effect upon the soil. It assists in making nitrogen and other plant foods soluble. Its application to heavy, sticky soils makes them more loose and open. Do you recall an experiment that proves this statement? Sourness and acidity are corrected by adding this element to the soil, usually in the form of lime.

The trace elements have proved to be of value in controlling plant diseases, and it has been shown that the addition of these elements has increased the plants' content of sugar, vitamins A and C, and their keeping qualities.

Exercise

What is the original source of the elements of plant food? How are they supplied to the soil by man? Do crop residues (stubble, roots, etc.) restore plant food to the soil?

Bacteria in the soil. The soil is teeming with life. Near the surface of the soil are to be found millions of bacteria. (See page 190.) The good work performed by these microscopic plants maintains the productiveness of the soil. They are exceedingly important in changing plant food into soluble forms. Some of the bacteria help to decompose the bodies of dead plants and animals, and thus increase the organic content of the soil. But harmful kinds of bacteria are also present. Fortunately, when the soil is in the best condition, those bacteria which are not useful are held in check. The desirable kinds of bacteria

require warmth, moisture, air, and food (humus). When the soil is cold, damp, and without air, the beneficial bacteria cease to function, and destructive forms become active. The soil must therefore be kept in good tilth.

Nitrification means the breaking up of the insoluble nitrogenous compounds of the humus to form soluble forms of nitrogen, or *nitrates*. Several useful bacteria attack the humus in the soil. Decomposition of the humus follows, and the nitrogen in it is combined with hydrogen to form ammonia. The ammonia is then changed to nitric acid, which unites with a mineral, usually calcium, to form a nitrate. The nitrate form of nitrogen is the one available to plants, as it is readily soluble in water. The bacteria which bring about these changes are collectively called

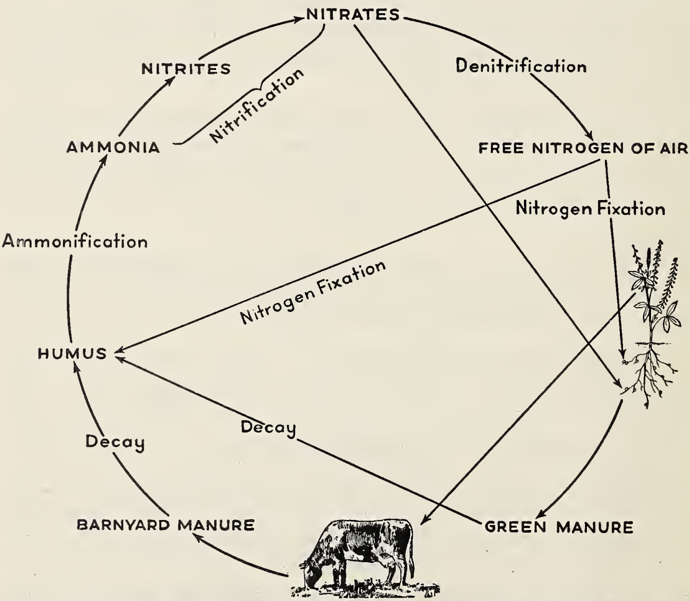


FIG. 9. The nitrogen cycle, that is, the movements of nitrogen between soil, plant, animal, and air.

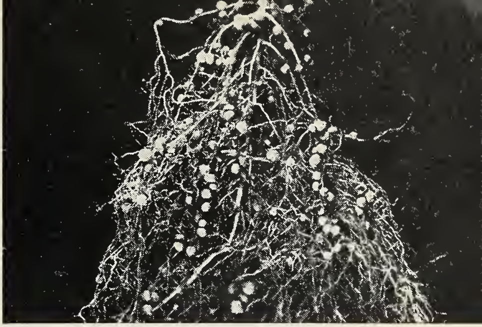


FIG. 10. Nodules on roots of a soybean plant. (Photo from Central Experimental Farm, Ottawa)

nitrifying bacteria or *nitrobacteria.* The rate of nitrification during the growing season influences very greatly the growth of crops. Good cultivation favours desirable nitrification.

There are in the soil, forms of *denitrifying bacteria* which change the nitrates back into insoluble forms or into free nitrogen that escapes into the air. This process is known as *denitrification.* These are harmful bacteria, and are not active when the soil is in good tilth.

Nitrogen fixation. The free nitrogen of the air cannot be used by most plants. However, certain bacteria, found only in the *nodules* on the roots of members of the legume family, are able to gather the nitrogen from the air and change it into a form in which it becomes available. This process is known as *nitrogen fixation.* Other bacteria, in no way connected with the legumes, have been found to be able to fix the nitrogen of the air, but these are not considered as important as the bacteria on the roots of alfalfa, clover, and related plants. (See pages 92 and 94.)

Problems

1. Name the elements essential to plant life. Where is each secured by the plant, and in what form is it taken into the plant?
2. How does each of the following influence plant growth: nitrogen, potassium, phosphorus, calcium?
3. Why are soil bacteria so important in crop production?
4. Compare nitrification and nitrogen fixation in respect to the bacteria involved, the nature of the process, and the place where the process occurs.
5. How may beneficial bacteria in the soil be encouraged?
6 What does the colour of a soil indicate in respect to its value for crop production?
7. Is an abundance of moisture in the soil more important than a good supply of available plant food elements? Give reasons.
8. State the value of soii surveys in various parts of the province. The Extention Department of the Agricultural College will advise you about soil surveys that have been made in your locality.

CHAPTER 2

SOIL PROBLEMS

"The fate of our present civilization hinges largely on what we do about soil conservation in the next few years."—G. R. Snyder.

Soil management should never be a haphazard undertaking; it should always be a scientific procedure based on the most up-to-date information available. Soil that is not producing well can often be made highly productive by managing it in a different way or by adopting measures to correct its short-comings.

Scientific method. You may find ideas and suggestions in this chapter with which you do not agree. If you find statements that are contrary to what you have always believed, do not reject them. When new, well supported evidence is presented to you, be prepared to change your opinions. A scientific attitude on your part should cause you to withhold your decisions in doubtful matters until you have searched for further authoritative information. Only when you believe that you have the true facts should you come to a conclusion.

A scientist never believes that he has the final solution to a problem. He continues to search for new information which may lead to new conclusions. It is this attitude that has produced the tremendous scientific advancement that has been made up to the present time.

The following is an example of how scientists change their opinions as a result of observation and experimentation. For many years, high yields have been accepted as evidence of a productive soil. However, agricultural scientists have recently demonstrated findings which indicate that a twenty-bushel crop of wheat may actually be a better yield of health-producing mineral and vitamin elements than a heavier crop. One cabbage

FIG. 11. The millions of bushels of wheat produced in Canada to help to feed the people of the world, remove annually from our soil immense quantities of elements essential to plant growth. (Photo from Canadian Industries Limited)

may have four times as much calcium as a second one of the same size and appearance.

These scientists say that the nutritional value of the food we eat depends to a large extent upon the mineral content of the soil upon which it was grown. The character of the soil upon which is produced the feeds that are provided for cows and hens may markedly influence the food value of the milk and eggs they yield.

These are new ideas. If we dismiss them lightly, we lack the scientific attitude. If, on the other hand, after reading independent articles supporting the statements, we are prepared to accept them as true and as evidence that more attention should be given to the vitamin and mineral content of our crops, we exhibit a scientific way of thinking.

The maintenance of soil fertility. A fertile soil is one which is capable of producing crops. Its fertility depends largely upon the supply of plant food elements in it; but its capacity to hold moisture and the cultivation received also influence its ability to produce crops.

The loss of soil fertility. It is a serious error to assume that the productiveness of the soil is inexhaustible. Every crop grown on a piece of land leaves the soil poorer by the amount of elements absorbed. The loss of soil fertility as a result of cropping is, of course, unavoidable; but by correct methods much can be done to reduce the waste and dissipation of the substance of the soil due to weeds, drifting, excessive cultivation (the amount of nitrogen that has been wasted by poor methods of cultivation is more than twice as much as that which has been removed by crops), dentrifying bacteria, *erosion* (washing of the soil by running water), and weathering.

Unless steps are taken to restore the organic matter and the available supply of essential elements, the soil will become impoverished. A good farmer feeds his soil as he feeds his live stock. The methods employed by farmers and gardeners to restore and maintain soil fertility are the application of commercial fertilizers, barnyard manure, green manures, and crop rotations, which include legumes and grasses, summerfallowing, or substitutes.

Commercial fertilizers. When the elements in the soil have become depleted, they may be restored by the careful use of specially prepared fertilizers. Gardeners and farmers now use tremendous quantities of fertilizers annually, though all soils do not respond equally well to such treatment.

Nitrogen is the plant food most commonly exhausted and most expensive to restore. Sodium nitrate (Chili saltpetre) may be used to replace it since it contains nitrogen in a very soluble form. Ammonium sulphate is another valuable source, but in this salt the nitrogen is not so readily available. Another common fertilizer is ammonium phosphate. By-products of the abattoirs, such as dried blood and tankage, are rich in nitrogen and phosphoric acid, and are sold under various trade names.

Nitrogen is frequently applied in special quantities to crops that produce a strong growth of stem and leaf, such as lettuce, cabbage, spinach, melons, and legumes. Active growth in young

FIG. 12. The effect of phosphorus on plant growth: phosphorus was supplied to the tobacco plants at the right, but not to those on the left. (Photo from Canadian Industries Limited)

plants is often stimulated by the use of a nitrogenous fertilizer, but too much nitrogen may retard maturity.

Bones are used extensively to supply phosphorus. These are usually ground or steamed to make the phosphorus more readily available. Certain phosphoric rocks contain moderate amounts of phosphorus and, when finely ground, often form the basis of phosphoric fertilizers. They are sometimes treated with sulphuric acid to produce super-phosphate, in which the phosphorus is quite soluble. *Basic slag*, a by-product of the manufacture of steel, is rich in phosphorus and lime and makes a splendid fertilizer. Phosphoric fertilizers are employed chiefly for crops of which the seed or fruit is used. Increased root development, stooling, and earlier maturity generally result.

To produce potash fertilizers, potassium salts are obtained from various parts of the world (Germany, France, California, etc.). A rich source of potash is wood ashes. Muriate of potash is another potassium fertilizer. Potassium fertilizers are used for root or tuber crops, such as turnips, beets, or potatoes.

Calcium is applied to the soil by the use of slaked lime or finely ground limestone.

Fertilizers containing sulphur are valuable for gray soils, especially when legumes are being grown.

All fertilizers are sold under the control of the Plant Products Division of the Dominion Department of Agriculture. An analysis of the fertilizer must be shown on the bag. A short method of indicating the percentage of each element is commonly used. For example, a 9-27-9 fertilizer contains 9 per cent nitrogen, 27 per cent phosphoric acid, and 9 per cent potash. The first figure always refers to nitrogen, the second to phosphorus, and the third to potash.

The benefit to be derived from the use of fertilizers in flower and vegetable gardens and in grain fields is now an established fact. Because of the longer period during which the soil has been used, and the more intensive nature of the crops that are grown, Eastern Canada has made more widespread use of fertilizer than have the Prairie Provinces. However, even in the grain-growing areas of Western Canada, increased yields have resulted from the judicious use of commercial fertilizers. Triple super-phosphate and ammonium phosphate have been particularly effective. Phosphate fertilizers have been found to encourage root development, stooling, and early maturing, and this tends to reduce materially the risk of damage from root-rots, weeds, insects, rust, and frost. The fertilizer should be sown with a proper drill attachment and usually only on summerfallowed land. From twenty to thirty pounds per acre are commonly used—usually lighter, drier soils require less, and heavy wet soils somewhat more. The use of fertilizers in the orchard is discussed on page 150.

Farmers and gardeners, as well as students interested in fertilizers from a practical standpoint, should write for information to the nearest experimental farm, agricultural college, or local Agricultural Representative. Varying conditions necessitate different procedures in applying fertilizers and produce different results; for example, in the northern gray soil areas they will not be the same as in the black soil park belt or in the drier areas where the soil has a medium texture. Fertilizers should not be depended upon to restore fibre or organic matter to the soil.

NOTE.—Experiments are being conducted (1949) to investigate the possibilities of applying a mixture of fertilizer and fungicide to supply essential elements and control certain diseases such as black rot of sugar-beets, or a mixture of fertilizer and insecticide to control wireworms and other soil inhabiting insects.

Watch for further information relative to these and similar investigations.

Barnyard manure. Barnyard manure is useful in restoring phosphorus, potassium, and especially nitrogen to the soil. It also returns humus, which improves the water-holding capacity of the soil, binds the soil particles together, encourages the activity of beneficial bacteria, and helps to ventilate the soil. The amount of plant food elements in manure varies according to the amount of straw present, but it has been estimated that one ton of manure contains approximately ten pounds of nitrogen, eight pounds of potassium, and three pounds of phosphorus. Manure should be handled carefully to secure its full value. It should never be left where it can be washed or leached by rain, as this reduces its value as much as fifty per cent. The most economical practice is to get the manure on the land as soon as possible, providing there are no injurious weed seeds present. Rotting destroys the weed seeds, but results in some loss of nitrogen.

Manure is the most efficient of all fertilizers. All crops are improved by applying to the soil from ten to twelve tons of manure per acre once in three to six years. Over-manuring should be avoided. Applying manure in the spring to land in which potatoes are to be grown is unwise as it increases scab disease on the tubers. Best results are obtained by applying manure as far in advance of planting time as possible.

Green manuring. A good method of increasing the organic content of the soil is to sow sweet clover, alfalfa, soy-beans, peas, barley, oats, millet, or other leafy quick-growing crops and, when a growth of about six to twelve inches is reached, to plough it under as green manure. By doing this the fibre manufactured by the crop is put into the soil. This is more effective if the crop is not ploughed under until it is more mature. The practice of

green manuring results in improved humus content and soil fertility. In some areas, green manuring is considered an essential practice in orchard management.

Summerfallow. In summerfallowing, the land is not cropped but remains idle for a year in order that as large a percentage of the annual rainfall as possible may be stored in the soil for the crop that follows. This is the chief purpose of this practice in most areas. In many regions, summerfallowing is practised also to destroy weeds. If weeds are permitted to grow, the chances of building up a reserve of moisture are seriously reduced. The frequency and depth of cultivation should be just sufficient to control weed growth. By beginning summerfallow operations early in the spring, the possibility of increasing the moisture reserve is greater, and an additional benefit may result in the control of some insect pests. (See chapter on insects.)

Although summerfallowing is recommended as an essential practice on the farms of Western Canada, it should be remembered that, unless it is well managed, the benefits may be seriously reduced. For example, cultivating soil when it is dry causes it to pulverize, and this increases the possibility of soil drifting.

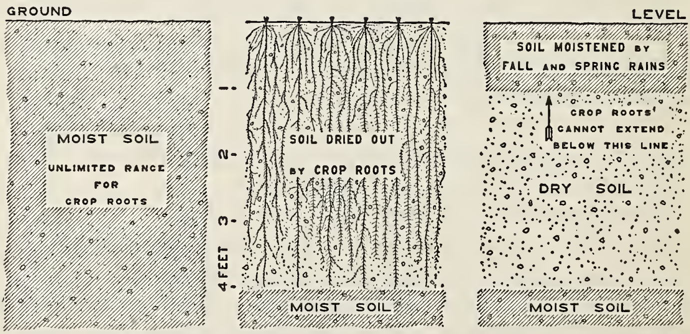


Fig. 13. This diagram illustrates how roots of a crop use up soil moisture and how little moisture is restored by fall and spring rains. (From a Report by Dr. E. S. Hopkins, Dominion Field Husbandman)

FIG. 14. Sheet erosion on summerfallow land will eventually cause gully erosion. The cause is a lack of trash cover in the soil due to improper cultivation. (Photo from P.F.R.A.)

No crop is produced while land is being summerfallowed, and the expenses of cultivation are high. Good management, therefore, is essential. The disadvantages may be overcome or reduced by methods such as the following: The summerfallow may be cultivated without ploughing as outlined on page 38. A ploughless summerfallow not only reduces the danger of soil drifting, but, if done at the right time, it also tends to reduce the damage caused by wireworms and cutworms as well as grasshoppers and sawflies. Under certain conditions one tillage operation may be done in the fall preceding the summerfallow. For example, to eradicate wild oats, the seed may be barely covered by means of very shallow cultivation in the fall to encourage early and heavy germination the following spring. This provides an opportunity of destroying the wild oat seeds which might not otherwise germinate until the land is in crop the following year. If possible, discuss summerfallowing with your local Agricultural Representative or with outstanding farmers of your district.

The implements recommended for a ploughless summerfallow are: the duckfoot cultivator, blade type weeders, the one-way disk, the one-way disk harrow, and the rod weeder. (See page 116.) The blade or chisel type of tillage implement is preferable to the disk type because it leaves the trash on the top of the soil and does not pulverize the soil as much.

In order to destroy perennial weeds, such as Canada thistle, it may be necessary to have a black summerfallow (that is, to

keep the summerfallow entirely free of green plant growth). With this practice, however, there is danger of soil drifting. Canada thistle and similar perennials first establish themselves in small patches. To eradicate the weeds the patches should be marked in the summerfallow field and cultivated every week to ten days; then, if the patches are small and not too numerous, straw or manure may be spread over them to prevent the soil from blowing. Some of the weeds may be successfully treated by means of chemicals, thus reducing the danger of soil drifting. During the summer, the fallow should be cultivated just enough to control the weeds. Cultivator ridges and clods will serve to check soil drifting. Intertilled crops, such as corn, sunflowers, oats, or barley, in double rows three feet apart, are useful. The advantages of intertilled crops as substitutes for bare fallow are that cultivation may be carried on between the rows, weeds destroyed, moisture conserved, and plant food made available, but the soil, being covered, does not blow.

It should be understood, however, that summerfallow practices necessarily vary a great deal in different localities. Methods that are practical on some farms will not be satisfactory on others. Each farmer should follow methods suited to his own particular conditions.

While summerfallowing is something that is a regular part of Western Canadian farming, the larger moisture supply in Eastern Canada has made the practice relatively unnecessary there. But it is very common for eastern farmers to continue cultivation throughout most of the summer in order to control weeds. Before the end of the summer, however, the land is seeded to some crop such as fall buckwheat.

What methods of summerfallowing are the farmers in your locality following? Methods of cultivating the summerfallow are discussed later in this book in sections dealing with soil drifting, weeds, insect control, etc.

Breaking. *Breaking* means the first cultivation of new land. Prairie should be ploughed shallow early in the year. The

furrow should be laid quite flat, and it is usually advisable to pack the land immediately after ploughing. During the summer, the soil should be well disked and harrowed to conserve moisture and destroy grass and weeds. When the soil has become well rotted, it should be backset or ploughed again, disked, and harrowed. In many districts the practice is to plough deeper at first without backsetting. Thorough cultivation later is necessary to ensure success by this method. Frequently a crop such as oats, flax, or wheat is sown on breaking.

When scrub land is being broken, it is ploughed deep early in the season, and packed, disked, and harrowed during the remainder of the summer. It is not ploughed the second time until the following year or later, in order to give the growth ploughed under, time to rot. Large trees may be cut down by hand or with a brush cutter, burnt off, or pulled down by a chain and a tractor or horses. Smaller trees and bushes may be drawn under the furrow and buried by means of a chain attached to the plough.

The cultivation of stubble land. There are many methods employed to prepare stubble land for another crop. One practice is to plough the soil and follow this operation with some form of surface cultivation, such as harrowing. Stubble should not be burned off land. Before it decomposes it serves as a trash to prevent soil drifting, and finally is a source of essential plant food elements.

In humid regions, or in wet autumns, fall cultivation is usually satisfactory for the loam type of soils but may cause drifting of sandy soils and some clay soils. It also breaks down the stubble so that less snow is held. Better results are obtained if fall ploughing is done early and to a good depth, unless shallow cultivation is required for some special purpose.

In dry districts, or following dry summers, spring tillage has several advantages. When the land is tilled in the spring and the crop sown shortly afterwards, there is less time for the soil to become dried out.

Stubbling in is the practice of sowing the crops on stubble land with very little or no cultivation. When an abundant supply of moisture is available, good returns are frequently obtained, but stubbling in is not advisable unless the land is very clean and in a good state of tilth. This method of sowing crops encourages the development of such insects as the wheat stem sawfly and is condemned on this account.

Good results are being obtained in a number of localities from cultivating and seeding stubble in one operation by means of a one-way disk with a seeder attachment (see Figure 71) or a tiller-combine.

Crop rotations. Many benefits result from the practice of *rotating crops*, that is, growing different crops in a recurring succession of a definite order. If any crop is grown continuously on a piece of land, the plant food elements will eventually be reduced and the crop will no longer do well. But when crop rotations are practised, a more balanced removal of plant food results, and the productivity of the land is more likely to be maintained. Grass crops, for example, because of their dense root systems, will replace the organic matter and fibre destroyed by grain crops, and legumes will replace nitrogen. Weeds, insects, and plant diseases, such as take-all root-rot of wheat, flax wilt, and blackleg and scab of potatoes, are checked, if not wholly controlled, by a succession of different crops. If more than one kind of crop is grown, the loss of the entire crop is prevented, because it is not likely that all will be a total failure in any one season. Not all crops are planted and harvested at the same time, and the practice of crop rotations makes it possible to arrange the work of the farm more evenly throughout the entire year.

A rotation of crops may include: a cash crop (in Western Canada, usually wheat or other cereal); an improvement crop (grasses or legumes); a cleaning crop to destroy weeds (summer-fallow or intertilled crops); and a feeding crop. Whether cash or feeding crops are emphasized will depend upon climatic conditions and the purpose for which the farmer carries on his enterprises.

On grain-growing farms, the main crop should be a cash crop, that is, one that will give a cash return to the farmer. Why? The cash crop is exhaustive, and should be followed by such crops as legumes, grasses, or intertilled crops, that will improve and clean the soil. Deep-rooted crops should succeed shallow-rooted crops. To make the most profitable use of grass or legumes, where they are grown to any extent, live stock should form a permanent part of the farm system. In Ontario and other parts of Eastern Canada, crops for feeding live stock comprise the chief crops in many of the rotations employed.

The system of growing other crops along with wheat and keeping live stock, instead of the practice of exclusive grain-growing, is called *mixed farming*. Continuous wheat-growing has robbed the soil in Western Canada of much of its fertility, and farmers are beginning to realize that mixed farming is the only method by which the soil in time will not become totally impoverished. Mixed farming means, "Wheat for sale; oats and other feed crops for live stock; poultry, hogs, and sheep to utilize waste products and coarse grains." In a later chapter, mixed farming is discussed more fully and compared with other systems of farming.

Examples of rotations suitable for the Prairie Provinces. The two types of farming practised in the Prairie Provinces require different types of rotations. Grain growing rotations: (1) Grain alternating with summerfallow is used in extremely dry areas, where the conservation of moisture is an important consideration. (2) In the greater part of the grain-growing areas, a three-year rotation—grain, grain, and summerfallow—is practised. This rotation provides for large areas of cash crops (mainly wheat), controls weeds, and conserves moisture. On the other hand, it encourages soil drifting and makes no provision for the return of fertility to the soil. (3) An example of a four-year grain-growing rotation is wheat, wheat, oats, summerfallow.

Mixed farming rotations will vary considerably from those outlined in the foregoing paragraph. (1) This four-year rotation

will suit certain localities: summerfallow or corn, wheat (seeded down to sweet clover), hay or pasture (ploughed in July), and coarse grains (oats or barley). (2) The following is an example of a good six-year rotation. The farm is divided into six fields of equal size. A different crop is grown on each piece of land, and every year each crop is moved up one field. Let us follow this rotation for six years in one field and see how it works out. The first year, wheat is sown. This is an exhaustive cash crop, and is followed by a grass or legume to improve the soil. Alfalfa, sweet clover, or grass may sometimes be seeded with the wheat to take advantage of the moisture stored up in the summerfallow. (See page 30.) The third year, live stock are pastured on the grass until midsummer, and the land is ploughed up and prepared for another wheat crop the fourth year. The fifth year a coarse grain crop, such as oats or barley, is produced. The sixth year the land is summerfallowed. As much of the summerfallow as possible should be planted to corn, potatoes, and root crops. Why? This rotation has been found to be very effective, especially in checking soil drifting.

Rotations for Eastern Canada. (1) A good three-year rotation suited to dairy farming is grain, clover hay, and corn. (2) Another rotation, adapted to a stock farm where all the crops grown are fed to live stock, includes a four-year succession of grain, clover hay, hay or pasture, and corn. (3) A useful six-year rotation is grain, clover hay, timothy hay, hay or pasture, hay or pasture, and roots or other intertilled crop.

Where a larger proportion of cash crops is desired, it is necessary to reduce the acreage of hay and pasture crops and substitute grain, potatoes, or clover seed. One grain-growing rotation suitable for certain parts of Ontario is wheat (a winter variety), clover for seed, barley, clover for hay, oats, summerfallow.

One should remember that there are many other combinations of crops which are good rotations for various types of farming and different soil and climatic conditions. A few only have been outlined for purposes of illustration.

NOTE.—A good bulletin on crop rotations is *Crop Rotations and Soil Management for Eastern Canada,* Bulletin No. 163, which may be secured free from the Publicity and Extension Branch of the Department of Agriculture, Ottawa.

In Saskatchewan, see *Guide to Farm Practice in Saskatchewan,* issued periodically and distributed free by the Extension Department, University of Saskatchewan, Saskatoon. Every school should have a copy of the most recent issue of this publication.

Exercises

1. In the six-year rotation outlined on page 36, how many fields each year are sown to wheat, to grass or legumes, to oats or barley, or are summerfallowed?

2. Explain what effect each crop in the above rotation will have upon the soil.

3. Would the fertility of the soil be reduced or not, after this rotation had been in use for eighteen or twenty years? Give reasons.

4. Draw a rectangle about four by six inches in size. Divide it into six parts to represent the fields of the above rotation. In each field neatly print the names of the six crops, one below the other. Place the name of the crop being grown in the current year at the top of the list in each field.

5. How should the fields on a farm where crop rotation is practised, compare in size?

6. Would a series of crops such as wheat, oats, barley, and rye be considered a good crop rotation? Why?

7. Approximately two-thirds of the nitrogen in an alfalfa plant is in the top and one-third in the roots and stubble. How much nitrogen will there be (*a*) in the top and (*b*) in the roots and stubble of a crop of alfalfa yielding two tons of hay? (Note: A yield of five tons of alfalfa per acre requires 238 pounds of nitrogen.)

8. About two-thirds of the nitrogen which legumes require is taken from the air. Is the nitrogen in the soil increased or not by a two-ton crop of alfalfa, (*a*) if the hay is removed and sold, (*b*) if the crop is ploughed under as green manure, (*c*) if the crop is cut and fed to live stock and the manure spread on the soil?

Note very carefully the facts brought out in Exercises 7 and 8.

Soil drifting. In many parts of the three Prairie Provinces soil drifting causes serious damage and has often totally destroyed

the crops on thousands of acres of land. The drifting particles of soil cut down the tender crops; germinating seed is buried so deeply that it never reaches the surface; the roots of the young plants are left uncovered and exposed to the killing influence of wind and sun; weed seeds are blown from one field to another; and the soil itself is injured by the removal of the top and often the most productive layer. It has been suggested that the last is the most serious loss. Roadways are blocked, ditches are filled, and fences become piled with the drifting soil. Life in farmhouses and even in towns and cities is made extremely disagreeable.

This serious situation is brought about in several ways. High winds cause drifting in areas in which dry, pulverized soil is unprotected by plant growth. Drought or other factors, which maintain the soil in a state favourable to drifting, are predisposing causes. Faulty farming practices are also responsible to a large degree. Too frequent or unsuitable cultivation reduces the land to a fine condition which permits the soil to be blown very easily. When prairie areas were first broken and cropped, soil drifting did not occur. But continuous cropping has robbed the soil of the fibre it contained when first cultivated so that nothing remains to bind the soil particles together. It is usually more difficult to control drifting of the heavy or light soils than of the medium-textured types.

To find a remedy for soil drifting is one of the greatest problems facing agriculturists today. If it is to be solved, more effective systems of farming must replace present practices. In combating soil drifting the following suggestions may prove helpful:

1. Implements that will leave the soil lumpy or in ridges and the plant trash on the surface should be used for cultivating.

2. In fields having stubble or weed growth, the practice of summerfallowing without ploughing should be followed. The land should be worked to form a "trash cover" and left in ridges in the fall. (See page 31.) In the case of a bare summerfallow on medium-textured or loam soils, fields are better ploughed or

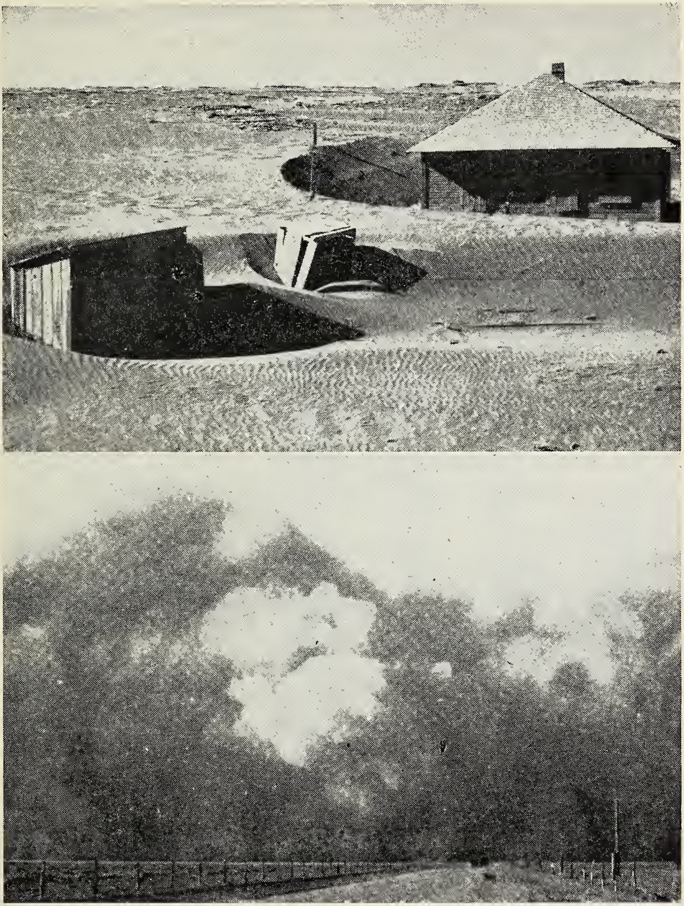


Fig. 15. It is difficult to believe, possibly, that dust can fill the air as shown in the lower illustration. It may also be difficult to think that the scene at the top was at one time a prosperous farm home. This farm lies in a severely wind blown area and has been devastated by continual movement of soil from badly over-grazed rangeland. The top soil has been completely removed. (Photos from U.S. Soil Conservation Service)

deeply ridged at certain distances. The cultivator might be used early in the season and ploughing or ridging done later, leaving a lumpy surface to stop drifting. Sandy or heavy soils cannot be handled in this way because they slake down. Intertilled crops, such as corn, should replace bare fallows wherever possible. Tillage should be reduced to the minimum necessary to control weeds.

3. Where they can be grown successfully, a place should be made in crop rotations for more grass and legume crops. It has been generally agreed that more live stock and more manure will keep the land in better condition. In Bulletin No. 179 of the Dominion Department of Agriculture, by Hopkins, Barnes, Palmer, and Chepil, it is stated that "humus in a soil appears to facilitate drifting." Humus has been found to prevent the soil from forming into clods or lumps. There appears to be no doubt, however, that mixed farming practices (grasses and legumes to restore fibre) will tend to lessen the danger of serious soil drifting.

4. The practice of *strip farming*, which originated in southern Alberta some years ago, has been found effective in preventing soil drifting. The land is cropped in strips, with alternating strips of summerfallow. The strips are usually arranged in a north-and-south direction, and vary in width from ten to twenty rods. In the summerfallow strips, it is important to follow, as far as possible, methods that will maintain the soil in a lumpy condition and protect it by a trash cover, as outlined in the discussion of the ploughless summerfallow (page 31). When strip farming is practised, it is necessary to take special precautions to control insects and to prevent the accumulation of drifted soil at the borders of the strips and the growth of weeds at the edges of the grain.

5. A light seeding of grain, sown about August 1st on summerfallow, will hold the soil for the remainder of the season and during the following spring. Wheat sown at the rate of one-half a bushel and oats and barley sown at the rate of three-quarters

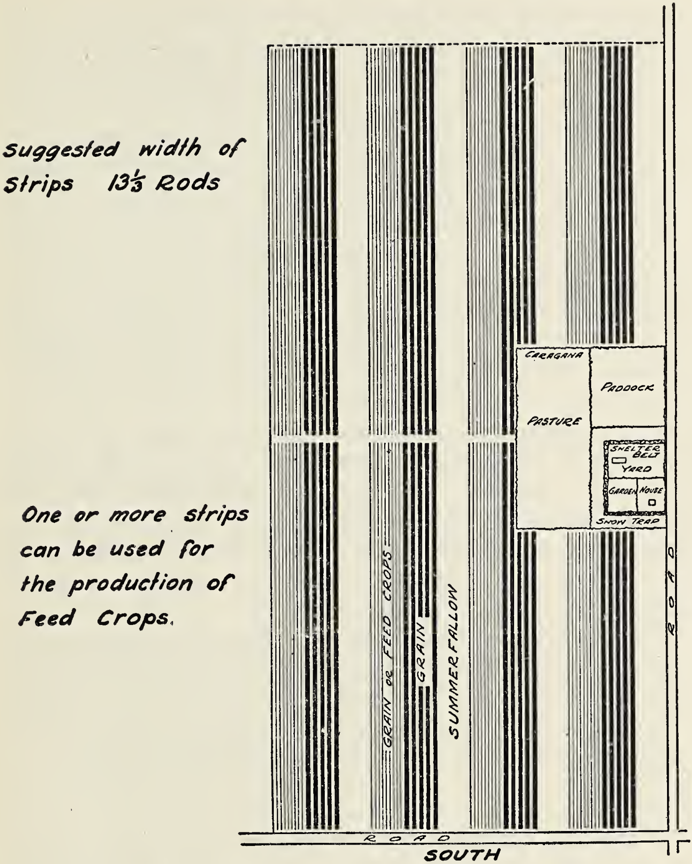


FIG. 16. A strip farming plan for a half-section farm. Arrangement of strips for a three-year rotation: summerfallow, grain, grain. The practice of strip farming is an example of a change in methods to meet an adverse condition. The system itself may have to be modified to combat successfully unfavourable factors which reduce production; thus the width and position of the strips may require adjustment from time to time. (From *Soil Drifting Control in the Prairie Provinces*, Bulletin No. 179, Dominion Department of Agriculture, Ottawa)

of a bushel per acre have proved to be effective "cover crops." Reduction of the moisture content of the soil and interference with cultivation to destroy weeds are disadvantages of this method of preventing soil drifting. Fall rye, which covers the soil in the fall and the spring, is a useful and recommended preventative.

6. It has been suggested that the prairies should be replanted with trees to reduce the velocity of the wind. Bulletin No. 179 of the Dominion Department of Agriculture discusses the value of a shelter belt of trees and the possible advantage of a strip of pasture around farm homes. The pasture and the shelter belt, however, require protection from drifting soil. This may be provided by a caragana hedge or several rows of sunflowers planted around the pasture or some twenty rods from the shelter belt.

7. In Alberta it is possible for a farmer to take legal action when his land is damaged by soil drifting caused by the carelessness of his neighbour. The Control of Soil Drifting Act, 1935, prescribes control measures and penalties. Saskatchewan also has a Soil Drifting Control Act passed in 1938. It would appear that co-operative community effort is necessary to ensure effective control of soil drifting.

Frequently, soil drifting begins in a relatively small part of a field. Prompt action will greatly reduce the tendency of such an area to spread. Effective measures are: covering with straw or manure, ridging deeply by means of a duckfoot cultivator, or ploughing furrows a few feet apart in and around the area.

Exercise

Methods of controlling soil drifting are largely determined by local climatic and soil conditions. Explain which of the recommended methods of control are found to be most effective in your district.

Water erosion. Before man tore into the soil with cultivating tools, Nature provided a covering of trees, shrubs, and grass that effectively protected the land from the harmful effects of running

water. But when the soil was put under cultivation, it was often left bare and unprotected. As a result, soil damage by water erosion has become increasingly serious and critical. Practically all types of soil lying in sloping positions, in cultivated fields or in pastures that have been eaten too short by over-stocking, are subject to injury after heavy rains or quick thaws. Not only may the best top soil from a field be washed away in enormous quantities, but deep gullies that seriously interfere with cultivation may develop. (See Figure 17.)

The faster the speed of the water, as on steeper slopes, and the greater the volume, as on long, relatively gentle slopes, the more harmful the resulting damage will be.

Three types of erosion may occur:

1. *Sheet erosion* takes place on the upper slopes and is least likely to be observed, but it results in a more or less uniform removal of the top soil, and seriously reduces the productivity of the land. (See page 31.)

2. *Rill erosion* develops where slopes are steeper and results in the formation of miniature gullies. The consequent damage may be very great.

3. *Gully erosion* is the final of the three stages. It produces water channels so extensive that cultivation becomes difficult.

Methods of control include both cultural and cropping practices which maintain a protective cover of stubble or grass and thereby prevent water from flowing over the land.

1. Land under cultivation should be tilled in such a manner that stubble and plant trash are anchored at the surface of the soil. Thus the flow of water will be retarded, and the land will absorb water readily. Bare summerfallow should be avoided.

2. Contour strip farming, where practical, is effective. Both the crop strips and the tillage should be across the slope instead of up and down.

3. The steeper slopes, where erosion is difficult to control, should be permanently seeded to hay or pasture crops. This is especially necessary where gullying has occurred; and where

gullies are being formed in cultivated fields, the sides of the gully should be sloped gently before seeding.

4. In some cases, the water from the upper areas may be diverted by terraces and dams before it reaches the gully.

5. It may be possible to control weeds by means of chemical sprays, thus reducing the need for cultivation and the attendant danger of water and wind erosion.

Alkali soils. These are soils containing such large quantities of soluble salts that plants cannot grow in them. They are most common in areas of light rainfall or poor drainage. These conditions allow the salts to accumulate in the soil instead of washing them away. The salts are carried upward by the capillary rise of soil water, and deposited on the surface as the water evaporates.

Two kinds of alkali are found. White alkali is a mixture of sodium sulphate (Glauber's salts), magnesium sulphate (Epsom salts), sodium chloride (common salt), and a number of other salts. When sodium carbonate (washing soda) is present in the mixture, it dissolves the humus in the soil, darkening the salts which are then called black alkali.

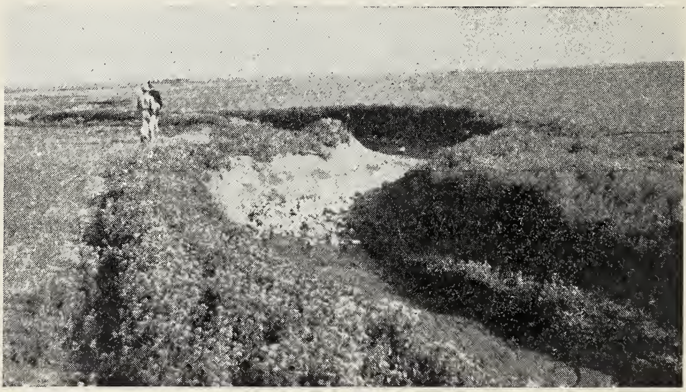


Fig. 17. Serious gully erosion has cut up this field badly and made it impossible to use farm implements properly. (Photo from P.F.R.A.)

FIG. 18. This pleasant farm home is situated in a location where soil erosion could be very serious. However, the farm has a complete soil conservation programme in operation. All tilled land is contour strip cropped. The hay meadows are treated and seeded to good mixtures. The pastures are fertilized and mowed for weed control. The farm is liberally planted with trees. Neither wind nor water can damage the soil. (Photo from U.S. Soil Conservation Service)

Alkali makes the soil solutions so strong that plants cannot use them. (See experiment on osmosis, page 58.) The structure of the soil is broken down, and the soil is reduced to a very fine, powdery condition. Black alkali destroys humus and even attacks the roots of plants. Some salts occasionally found in spots which have an alkaline soil are *toxic* or poisonous to plant growth.

To correct the alkaline condition of the soil, it is first necessary to change the black alkali, if present, into white. This is a chemical change—the sodium carbonate is changed into a less harmful white alkali salt. It is accomplished by using calcium sulphate (gypsum or land plaster) at the rate of one ton per acre. The land should then be drained, if possible, to carry the alkali away. From six to ten tons of strawy manure are next disked deeply into the soil. What effect will the manure have on the soil?

Thorough cultivation should be carried on during the remainder of the season to prevent the capillary moisture from depositing more salts on the surface. Irrigation assists in washing the soil free of alkali.

The best crops to grow first on reclaimed alkali land are sugar-beets or mangels. These were originally salt marsh plants and have become adapted to alkaline conditions. If the alkali is not too strong, oats, barley, sweet clover, or western rye grass may be grown.

Exercises

1. Mix a little soda or common salt with some fine soil. Tie cheese-cloth over the bottom of a lamp chimney or wide glass cylinder, and fill it with the mixture. Place the container in a vessel of water as described in the capillary moisture experiment on page 13. Keep a good supply of water in the lower vessel. After a week allow the surface of the soil to become dry. Notice the salt that has been deposited there by the water. Using the results of this experiment, explain how alkali salts accumulate at the surface of the soil.
2. Explain the direction in which osmosis would take place if the strong solutions were outside of the plant.
3. If there are alkali spots in your district, arrange to visit one or more. Notice if plants are growing there. Are the spots in high or in low locations? Would it be possible to drain the spots? Examine the soil. Collect samples, and apply the test described on page 5.
4. In districts where there are alkali spots, it is found that in wet years there is less alkali in the soil than in dry years. Explain.

Irrigation. Irrigation is the application of water to the land to increase crop production. In Canada irrigation is confined chiefly to the western areas. In southern Alberta and in parts of south-western Saskatchewan the rainfall is so light that, although the soil is good, profitable crops cannot be produced. To use this land for gardens or field crops, water from rivers or from dams may be supplied by irrigation. The water is delivered to the dry areas by means of large ditches or canals. To control the flow of the water, locks or gates are built at intervals along the ditches.

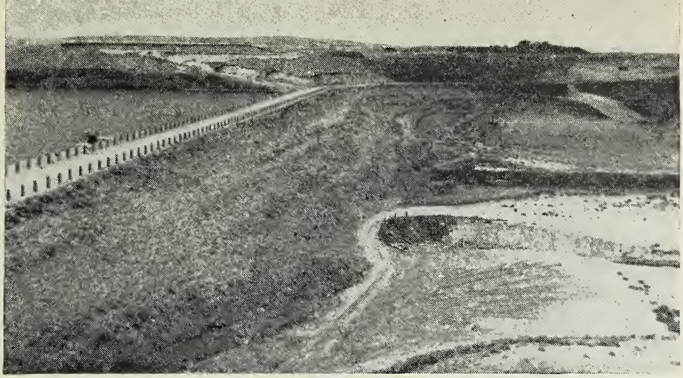


FIG. 19. View of Earthfill Dam across the Swift Current Creek, Saskatchewan. With a maximum height of sixty-eight feet, this is one of the highest earth-filled dams in Canada. It creates a reservoir with a storage capacity of 85,000 acre feet of water, and will provide water for some 25,000 acres of land in the Swift Current irrigation project. It was completed in 1943. (Photo from P.F.R.A.)

From the main ditches, small laterals carry the water to all parts of the country to be irrigated.

Different methods are used by farmers to spread the water from the ditches over their fields. One way, known as *free* or *wild flooding,* consists of turning the water into a field at a high point and allowing it to spread out over the field. Such a system wastes a great deal of water and does not flood the land evenly.

A more common practice is that known as *controlled flooding,* which is accomplished by means of contour ditches. Farm ditches are located on the contour of the land with enough slope to carry the water. These ditches are spaced according to the slope of the land, the kind of crop, and the amount of water the farmer receives. The water is then flooded from one ditch to the next. This gives a more even irrigation than the method of free or wild flooding.

A more advanced practice is that known as the *border system.* The field is divided into strips by ridges of soil, two or three feet wide and four to six inches high in the centre. The ridges are low and flat enough to be seeded to crop. They are located down the greatest slope of the land, and the land between the ridges is levelled, the land sloping only in the direction in which the ridges run. These strips have contour ditches crossing them at regular distances; and when the water has flooded one strip, it is turned

Fig. 20. Irrigation projects make it possible to provide water for "thirsty" crops at times when the greatest good will result. This illustration shows how furrow irrigation is carried on. (Photo from National Film Board)

into one of the ditches and used to flood the strips lower down the field. This method is particularly advantageous for hay and pasture fields.

Another system, known as *furrow irrigation,* carries the water over the field in furrows. This method is used for intertilled crops and in gardens. The rows should run in the direction of the slope of the land. The water runs down the cultivated area between the rows of crop, and soaks into the soil. After each irrigation, as soon as the soil is dry enough, the crop is cultivated, unless it covers the land so that cultivation is impossible. In any system of irrigation, the land should be as level as possible; this reduces the labour of applying the water and gives a more even and rapid application.

Fall irrigation gives very satisfactory results and is highly recommended. During the summer, grain crops should be irrigated only if necessary, but at no time should the crop be allowed to suffer through lack of moisture. In Western Canada, alfalfa is the basis of successful irrigation farming. It should be irrigated in the fall and after each cutting. Grass crops require light, frequent irrigations, as they use a large quantity of water during the season. The soil should be thoroughly soaked for each irrigation. For grains, alfalfa, and grasses, the average application

is about six inches for each irrigation. For cultivated crops, the average application is about three inches. The crop usually requires water if the soil up to a depth of ten or twelve inches falls apart when squeezed lightly in the hand. The best practice is to apply water early and not to allow the plant to suffer through lack of moisture. The number of applications of water required varies from one in a moist year to two or three in drier seasons. Care should be taken not to over-irrigate, as this is liable to produce a water-logged soil by causing a rise in the water table. (See page 12.) Over-irrigation may also develop an alkaline condition of the soil, as described on page 44.

Students may wish to consult bulletins from the Dominion and provincial Departments of Agriculture for further information relative to the stage of growth at which water should be applied to crops, the number of irrigations required by various crops, and the best time or times of the year to irrigate.

Rotations for irrigated areas. In areas where a farmer desires a long-time rotation he may plant alfalfa, which is not ploughed up for from four to five years after seeding, and follow it with sugar-beets, wheat, oats, and barley. In this rotation, some alfalfa is seeded down each year, and an equal amount is ploughed up. For a short-time rotation he may use sweet clover as a pasture and soil-builder, wheat, oats, barley, and some cultivated crops, preferably sugar-beets. In addition, he should have a field of alfalfa, which is ploughed up about six years after seeding. With each of these rotations the balance of the farm should be used for smaller areas of specialized crops and pastures.

Irrigation implies intensive mixed farming and the raising of specialized crops. Every part of the farm should produce each year. The crop rotation should be planned in order to use the water at all times and should include legumes such as alfalfa or sweet clover, intertilled crops (for which purpose sugar-beets are recommended), and some grain crops. Live stock are essential in any farm irrigation system.

Exercises

1. Arrange to visit an irrigated farm and have the farmer explain his method of irrigation.
2. What value will the crops recommended above have as cash crops or soil-improvement crops?
3. Increased yields have been reported in an experiment in California in which nitrogen in the form of ammonia was released into irrigation water at the time of the regular irrigation. The student should be on the alert for further similar announcements.

Prairie Farm Rehabilitation Act. Students who are interested in water and soil conservation should be familiar with Prairie Farm Rehabilitation Act (P.F.R.A.). This is a Dominion Act which was passed to help the farmers of the prairie drought areas of the 1930's to solve their problems by co-operative action. Attempts to grow wheat on land suited only for grasslands, and over-grazing (pasturing too many live stock on an area at one

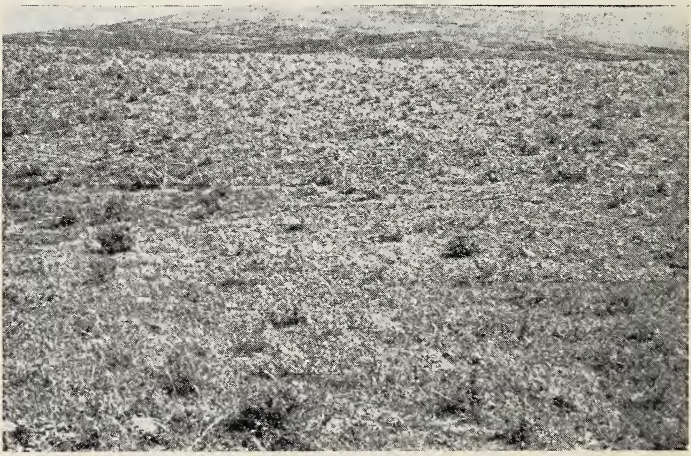


Fig. 21. Over-grazing of this range grassland has resulted in the disappearance of the native grass, the spread of a small shrubby plant, and extensive erosion on the hills in the background. A sufficient carryover of fall growth through the winter would have prevented the development of this condition. (Photo from Dominion Experimental Station, Swift Current)

FIG. 22. Typical farm dam construction on draws or coulees to provide water for stock-watering and domestic purposes, and in some cases for small individual irrigation schemes. (Photo from P.F.R.A.)

time) together with the drought, had resulted in disastrous soil drifting and crop failure. Numerous farms were abandoned, and large areas appeared to be developing into useless wastes.

The Prairie Farm Rehabilitation Act has already accomplished much in the three Prairie Provinces. Profitable farms and comfortable homes have been re-established. A programme of conservation and restoration is being worked out to develop in the Prairie Provinces a permanent system of farming which will ensure, as far as possible, profitable returns in all agricultural areas.

Numerous prairie farms are now provided with small dams and dugouts, to catch water from melting snow and heavy rains, and store it for use in times of drought, for watering stock, for irrigating gardens, and for household purposes. Larger irrigation projects are also being developed at the present time in many parts of western Canada.

In some districts, areas are being fenced, provided with stock-watering facilities, and resown to grass where necessary, to serve as community pastures. In these districts stock raising is emphasized, grain being grown only where conditions are favourable.

FIG. 23. P.F.R.A. farm dugouts are helping to increase production on many prairie farms. (Photo from P.F.R.A.)

Fig. 24. Yearling cattle on a P.F.R.A. community pasture. (Photo from Dominion Experimental Station, Swift Current)

The planting of shelter belts of trees around farm homes is also being encouraged.

Research projects being carried on by the P.F.R.A. include: soil surveys and investigations to determine the best type of farming for various kinds of soil; experiments in the use of native grasslands and the re-seeding of areas that have become bare or weedy; and studies to develop farming practices suitable for areas where ordinary cropping methods have not been successful, and to conserve moisture and prevent soil erosion.

Exercises

1. Visit P.F.R.A. projects in your locality. Find out what proportion of the cost was financed by the Dominion government through the P.F.R.A. and how much was financed by the farmer. Why were the projects undertaken?
2. Prepare a report to show that P.F.R.A. undertakings are co-operative. Why is co-operation essential?
3. Discuss the P.F.R.A., outlining (*a*) its objectives, and (*b*) its influence as time goes on upon the prosperity of the districts affected. In (*b*) give reasons for your answer.
4. To keep your knowledge of the P.F.R.A. up-to-date and complete, watch newspapers and other publications.

Drainage. Frequently the value of heavy, sticky soils or of soils in swampy, low-lying locations is reduced or destroyed by the presence of too much gravitational water. (See page 12.) If such soils are to be used for crop production, the excess moisture must be removed. This may be done by means of open ditches, or by under-drains, or tile systems. The under-drains are built by burying short lengths of tile or cement pipes, end to end, at a depth of from two to four or five feet below the surface of the ground depending upon the slope of the land. Water soaks down

through the soil and into the tile through the joints. For efficient drainage the tiles should have a fall of one or two feet in every hundred feet. The open drains are more cheaply constructed and give better results when a large volume of water must be removed; but they are continually becoming clogged with rubbish; they cause erosion of the soil; they use up land that could otherwise produce crops; and their banks are favourable growing places for noxious weeds. The under-drains are more satisfactory for permanent use. By efficient drainage many hundreds of acres of useless swamp land have been converted into profitable farms.

Exercises

1. What injurious effects upon the soil and plant growth has excessive gravitational moisture?
2. State the advantages of the tile system of drainage.
3. What results are being secured from the use of commercial fertilizers by farmers in your locality? What fertilizers are being used? Is the use of fertilizers in grain fields a profitable practice?
4. A thoroughly black summerfallow is required to eradicate certain perennial weeds well established in a field, but if the soil is infested with cutworms, there should be no cultivation from August 1st to September 15th. How should a summerfallow be managed to control both weeds and cutworms?
5. Why are crop rotations in the drier parts of the grain-growing areas of Western Canada limited to such as the following: wheat, wheat, summerfallow? What are the advantages and disadvantages of this and similar rotations?
6. Does irrigation in the drier parts of Saskatchewan appear to be practical? What sources of water are available? What has been done in recent years to improve the water supply in these districts? Discuss the P.F.R.A.
7. Why is it not necessary to irrigate land in the eastern provinces?
8. Does the situation in respect to soil drifting in Western Canada appear to be improving or not? Do you think it is possible to control soil drifting in the areas at present affected? Why?
9. Contrast the types of erosion found in the western provinces and those common to the rest of the country? How serious is erosion in Eastern Canada?

CHAPTER 3

BOTANY OF THE FARM AND GARDEN*

Plants play a very important part in our lives. In fact, all animal life is dependent, directly or indirectly, upon food materials produced by plants. A study of botany in a course in agriculture has value, therefore, since it helps us to understand the life processes of plants in relation to crop production and the feeding of live stock.

To understand how plants produce food it is necessary to know something of their structure and the function of their various parts.

The roots. The student should already know that the roots of a plant gather food (water and mineral matter in solution) from the soil, and carry these materials to the stem. The root also anchors the plant, and some roots (biennials and perennials) store food for future use.

Exercise

Compare the root of a wheat plant with that of a carrot. Notice the number and the comparative sizes of the branches or divisions of each root and the general direction in which they grow. Describe each root.

The wheat has a *fibrous* root, and the carrot a *tap* root. Wheat is an *annual* plant, that is, it lives but one year; its roots therefore, are annual roots. The carrot root lives for two years and is called a *biennial*. *Perennial* roots live for many years. A perennial or biennial root may be either tap or fibrous. Look for examples. The main part of a root is called the *primary* root, and the branches are *secondary* roots; the smaller parts of the roots are *rootlets*.

*This chapter may be dealt with as a separate unit or considered as required, in relation to topics in other sections of the book.

The root system. The root system includes all the roots of a plant. Its extent or size depends upon the kind of plant, the nature of the soil, and the depth of the moisture.

Project

When a plant is pulled out of the soil, most of the roots are torn off. Carefully dig up a plant, and gently wash the soil away. Do not hurry while you are doing this. Even with great care, many of the smaller roots will be lost. Divide the root among members of the class. Separate the parts, and lay the pieces end to end. Measure the length of each part, and add the results together to get the total length of the root system.

The roots of a wheat plant, when stretched out in this way, have been found to measure 600 yards. The root system of a pumpkin plant measures fifty times this length or over fifteen miles. Wheat, oats, corn, and other cereals may send their roots four feet or more into the soil to reach moisture.

Structure and function of the parts of a root. By examining carefully a typical root, much can be learned about the structure and functions of roots in general.

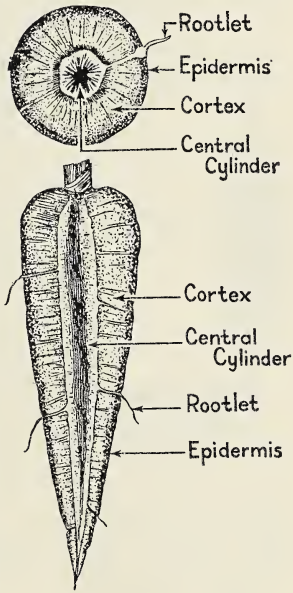


Fig. 25. A cross and a lengthwise section of a carrot. Look for the same parts in other roots.

Exercises

1. Using a sharp knife, cut a carrot crosswise and lengthwise. Observe in the centre a darker part. This is the *core* or central cylinder. Around the core is the *cortex*. Notice the thin skin or *epidermis* covering and protecting the cortex. If the carrot has been carefully taken from the ground, the small branches will remain attached to it. These are the rootlets. Observe that they spring from the core. Notice that the core leads to the stem.

2. Remove a piece of the cortex and taste it. What substance do you recognize? Pour iodine over the surface of a slice of carrot. A dark blue colour indicates the presence of starch. Observe carefully which part of the carrot turned blue. Taste a piece of the core. The slightly bitter or watery taste is due to the presence of mineral solutions from the soil. Does the structure of the carrot indicate which parts brought these solutions from the soil to the core? Are starches and sugars raw or manufactured foods? To which class do soil solutions belong?

3. At the tip of the root there is a tough *root cap* that fits over the end like a thimble. Place some geranium, tradescantia (wandering Jew), or willow slips in water, and notice the root caps on the roots that develop.

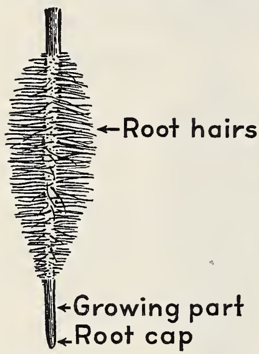


FIG. 26. The tip of a growing root.

The parts that have been observed in the roots of the plants examined in the foregoing exercises are found in all roots. Each part performs a special function in the work of the root. The rootlets and the root hairs (see page 57) gather the raw food from the soil and pass it along to the core, which in turn conveys it to the stem. The epidermis is the protecting cover that prevents the root from drying out. In some roots, such as the carrot, the cortex is a storehouse in which manufactured foods (starch, sugar, etc.) are stored for future use. The root cap protects the tender growing tip of the root.

Problems

1. Show how what you have learned about the storage of food in a carrot would be useful in judging carrots at an exhibition, or in selecting varieties of carrots from which to save seed for planting the following year.

2. "In the seventeenth century, farmers from the Netherlands introduced into England the cultivation of winter roots." Why was this an important step forward in British agriculture? How has man's knowledge of food-storage in roots helped him to feed his live stock? What roots are most useful for this purpose?

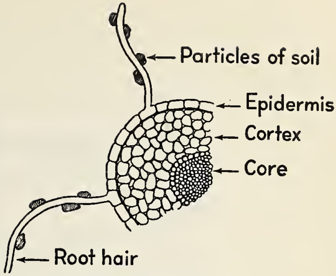


Fig. 27. A cross-section of a rootlet showing root hairs growing out of the epidermis.

Root hairs. As the name suggests, the root hairs are tiny members of the root system; but in spite of their minute size, they perform an important function.

Exercises

1. Place a few radish or wheat seeds loosely between sheets of moistened blotting paper. After three or four days examine them carefully. Notice that the young roots are covered with minute, white, hair-like out-growths. These are the root hairs. Very carefully place a root under a magnifying glass, and study the characteristics of the root hairs. (If a microscope is available, very small seeds, such as alfalfa, may be germinated far enough apart so that the roots will not tangle, and examined under low power on a slide without a cover-glass.)

2. Compare root hairs and rootlets with regard to size, structure, function, length of life, and the part of the root system from which they spring.

The root hairs are extremely delicate, long tubes that grow out of the epidermis of the rootlets and the tips of the roots. As a root grows older, it becomes covered with a tough, waterproof bark, and the root hairs along its length die and are replaced by new ones near the growing tip of the root. The root hairs are the chief food-gatherers of the root. If the roots of trees or other plants are exposed to the sun, as during transplanting, the tiny root hairs are quickly killed, and, as a result, the food-absorbing power of the plant is seriously injured.

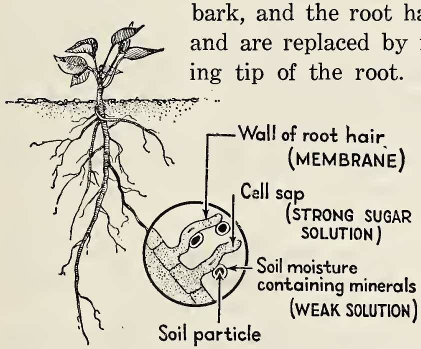


Fig. 28. A diagram to illustrate how roots secure water and minerals from the soil. A part near the tip of a branch has been magnified to show a few root hairs. (See page 58.)

How roots absorb solutions from the soil. The following experiment will show how roots obtain food to nourish the plant.

Exercise

Fill the bulb of a thistle-tube with molasses. (If the stem end of the tube is stopped by a cork or the finger and the molasses poured quickly into the bulb, the air trapped in the stem will hold the molasses in the bulb.) Over the mouth of the thistle-tube stretch and tie a porous membrane—cellophane or a piece of pig's bladder; soften each in water before using. Fill a beaker with water. Turn the thistle-tube mouth down, and fasten it to a stand so that the membrane is well under the water in the beaker. After several hours observe the following: the fall of the water in the beaker; the rise of the molasses in the thistle-tube; and the colour of the water in the beaker. Explain. In what direction has the greatest exchange of solutions taken place?

Arrange the apparatus, placing water in the thistle-tube and molasses in the beaker, and compare the results in this case with your observations above.

In an experiment such as the foregoing you will notice that a large quantity of the water soaked through the membrane into the molasses. This process is known as *osmosis*, which may be defined as the diffusing or passing of solutions through a membrane.

Under ordinary conditions, the solutions of sap in the plant are stronger than the solutions of plant food in the soil. Therefore the direction in which the solutions move is from the soil into the plant. The sap in the stem is forced some distance up into the stem by the incoming plant food. The food is then carried on up by other processes.

Exercise

Alkali soils are those containing large amounts of soluble salts. These salts make the soil solutions very strong. Very few plants can grow in alkali soils. Explain fully. (See page 45.)

Conditions necessary for the growth and work of roots. Moisture is one of the chief factors in promoting the growth of plants. Plants must have water, since plant food in the soil must be in solution before the roots are able to absorb it. They should

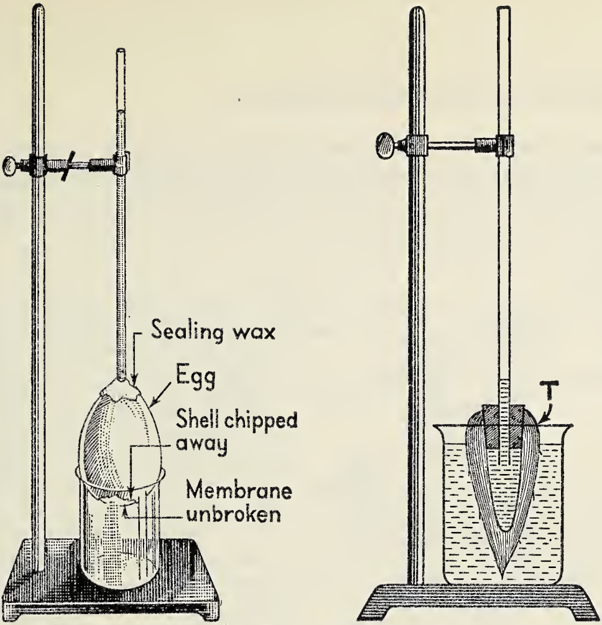


FIG. 29. These diagrams illustrate two osmosis experiments—the "egg" experiment and the "carrot" experiment. A third, the "thistle-tube" experiment is described in the text. To perform the carrot experiment bore a hole in a good-sized carrot and fill it with molasses. Insert a glass tube into a one-holed rubber cork, and fit the cork into the hole in the carrot. Be sure to bind the carrot tightly to the cork at the point marked T. Have a committee prepare this carrot osmometer to supplement the experiment outlined in the text.

not have too much water, however, for air too is necessary for growth, and water-soaked soils do not contain sufficient air for the roots. Notice that, when water is allowed to remain in a low spot in a field, the plants growing there become yellow and sickly in appearance. Warmth also is essential. Plants should not be watered with ice-cold water, for if the roots are chilled, the plants quickly wilt.

Problem

A knowledge of root structure and function will have practical value in many ways. Discuss the facts outlined in the foregoing section in relation to preparation of a seed-bed, depth of cultivation, type of soil suitable for early spring planting, soil drainage, irrigation, proper placement of fertilizer, planting distance, and reproduction of plants.

The leaves. The leaves perform three functions in the life of the plant; they manufacture food; they provide the chief "breathing" organs of the plant; and they enable it to get rid of excess moisture. (See Figure 46.)

Exercise

Prepare a beaker of boiling water. Dip a green geranium leaf into the water for a minute or two. Place the leaf in an evaporating dish, and cover it with wood alcohol. Set the evaporating dish in the top of the beaker. Be very careful not to spill the alcohol into the flame. Replenish the alcohol when necessary; one safe method of doing this is to remove the evaporating dish to a safe distance from the flame before adding the alcohol. In fifteen or twenty minutes observe the colour of the leaf and the alcohol.

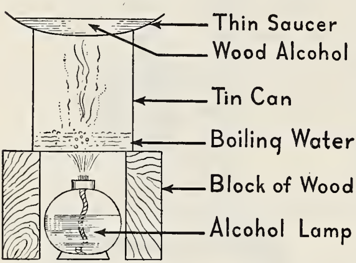


FIG. 30. A good method of removing the chlorophyll from a leaf in the experiment to find out if light is necessary for the manufacture of starch by leaves of plants. The leaf is submerged in the wood alcohol.

The green colouring matter dissolved from the leaf in the foregoing experiment is called *leaf green* or *chlorophyll* (klō′rō-fil). Before chlorophyll can be formed by the leaf, it must have sunlight.

Exercise

To demonstrate that sunlight is necessary to produce a healthy green colour in leaves, perform the following tests: (1) Place a plant in a dark cupboard, water it frequently, and notice the change in colour. (2) Germinate some radish seeds, keeping them completely in darkness. After a few days, observe the colour of the seedlings. Then place them in the light, and watch how quickly they become green. (3) Cover a small patch of the lawn with a board, and observe how the grass loses colour. (4) Examine some potato tubers which have been sprouting in the dark.

Green leaves contain starch. The following exercises show how its presence can be determined.

Exercises

1. Place a few grains of starch in a test-tube. Fill the tube with distilled water. Add a few drops of iodine. Notice the dark blue colour produced.

2. Set a plant away in a dark cupboard. After a day or more, take a leaf from this plant and another from a plant that has been in full sunlight. Dissolve the chlorophyll particles from the leaves. Place the leaves on a piece of glass, and apply the iodine test for starch. In which leaf is the presence of starch indicated?

3. Remove a leaf from a plant having leaves with white and green parts, such as a geranium or foliage plant. Test for starch.

From these experiments you will see that light and chlorophyll are necessary for the manufacture of starch; the relation of these to the starch-making process will be discussed more fully later.

Another function of leaves is breathing or *respiration*. The plant cells require oxygen, and the carbon dioxide produced by the processes that take place in the cells is a waste product and must be removed.

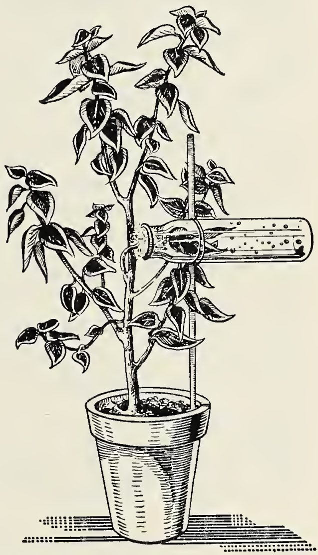


Fig. 31. An experiment to show how plants give off water through the leaves.

A third function of leaves is the giving off of water in the form of a vapour. This process is known as *transpiration*.

Exercises

1. Insert a few leaves of a potted plant into a small glass jar, as shown in Figure 31. Plug the mouth of the jar with cotton batting to exclude moisture from the air. Tie or clamp the jar to a stick or rod placed upright in the soil beside the plant. Water the plant well, and place it in full sunlight. After half an hour or more, observe the mist which has collected on the inside of the jar. Later

you will notice that drops of water gather, and finally run down the sides of the jar. A large quantity of water has been given off by the leaves in a short time.

2. Place a drop of alcohol or gasoline on the back of your hand, and observe the cooling effect that is produced as it evaporates.

Water is very important to plants. A very large quantity of water passes off from the leaves of plants. It has been estimated that a plant requires from 200 to 500 pounds of water in order to produce one pound of dry matter. (See problem on page 11.) Water is the agent that dissolves the plant foods in the soil, thus changing them into a form available to the plant. It transports food material from one part of the plant to another. It keeps the plant turgid and erect. When the roots send up enough water to keep the cells of the leaves and stem pumped full, the cells are rigid; but if the roots fail to maintain the water pressure, the cells become dry and collapse, and the plant wilts. Water provides hydrogen and oxygen for making starch. The transpiration of water from the leaves helps to keep the plant cool. Without water, the functions of the leaves cannot be carried on.

Problem

Weeds are responsible for the chief controllable loss of soil moisture. Discuss this statement in relation to transpiration and the importance of water in the lives of plants.

The manufacture of carbohydrates. The roots of a plant send up water (H_2O), which is composed of hydrogen and oxygen. During the day the leaves absorb carbon dioxide (CO_2), a compound of carbon and oxygen. The chlorophyll particles absorb *energy* (power to do work) from the light. The energy is used by the leaves to produce *carbohydrates* (starch and sugar) from the water and the carbon dioxide. (See page 256.) This process is called *photosynthesis* (fō-tō-sin′the-sis), which means to put together by means of light. Sugar is produced first, then starch. Some of the oxygen is left over and is given off as a waste product.

The process of photosynthesis may be represented as follows: 6 molecules of carbon dioxide (6 CO_2) combine with 6 molecules

of water (6 H_2O) to produce 1 molecule of sugar ($C_6H_{12}O_6$) plus 6 molecules of oxygen (6 O_2):(6 CO_2+6 $H_2O \rightarrow C_6H_{12}O_6$+6 O_2).

The transportation of carbohydrates. Water is the solvent in which food materials are moved from one part of the plant to another. Starch is not soluble in water, but for the purpose of transportation it is converted into sugar by an enzyme in the leaf. The process of changing starch to sugar is called *digestion* and corresponds to digestion in the animal body. Sugar readily dissolves in water and is distributed to all parts of the plant.

The uses of carbohydrates. If the juice and the pulpy part are squeezed from a plant, the tough, woody cell walls are left. These are composed of a material called *cellulose*, which is largely carbon. Other carbohydrates have been used to produce the cellulose. Wood consists chiefly of carbon. The leaves combine carbohydrates with nitrogen, sulphur, and a little phosphorus to produce a food compound called *protein*. (See the test on page 255.) Some of the carbohydrates are also broken up and rebuilt into fats and oils. The world's supply of food depends upon the process of photosynthesis. More carbohydrates and other materials manufactured in the leaves are used to produce *protoplasm*, which is the living material of all active cells. It is a clear, semi-fluid substance and may be seen under a powerful microscope.

Problem

Of what importance to a farmer is a knowledge of the cellulose, carbohydrate, protein, and fat content of plants?

Storage of starch. Carbohydrates not needed at once by the plant are stored, usually as starch, for future use.

Exercise

Name the various parts of plants in which you know that starch is stored. Test a potato, a carrot, and an onion for the presence of starch. Notice how these parts are modified and enlarged to make suitable storehouses. Give reasons for the storage of starch. Do annuals store starch? What plants do?

When starch is stored in any part of a plant, the part becomes larger. The large fleshy roots of carrots, turnips, parsnips, etc.,

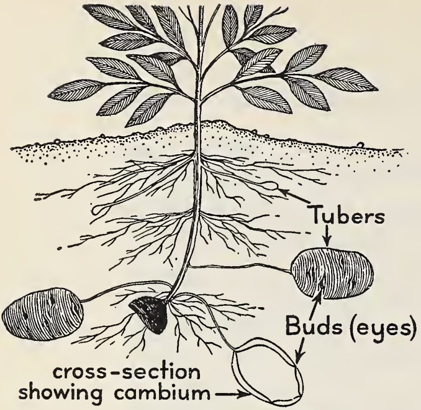


FIG. 32. The root system and tubers of the potato. The tubers are not roots, but are the swollen ends of underground stems. Another example of underground stems is illustrated in the diagram of the thistle, on page 180.

are good examples of this. The leaves of onions and cabbages are thick and fleshy because of the quantities of starch stored in them. Potatoes are underground stems. (See Figure 32.) Notice how swollen they are with their supplies of starch. Starch may be stored in leaf, stem, or root. As a plant matures, the starch gradually finds its way into the seed.

The breathing pores of the leaf. How do the gases, carbon dioxide and oxygen, pass in or out of the leaf? From what part of the leaf does transpiration take place?

Exercise

Using a sharp knife, carefully remove a small piece of the epidermis from the under-side of a fresh geranium leaf. A piece about one sixteenth of an inch square is more than enough. Prepare a slide from it and examine it, first under the low-power lens of a microscope, and then under the high-power lens.

To prepare the slide, carefully clean the cover-glass and the slide. Place the piece of epidermis on the slide, and with the point of a pen-knife drop a small quantity of water on it. Then carefully set the cover-glass over the material, and gently press it with the knife to squeeze out any air bubbles that may have been formed. The slide is now ready for the microscope.

Notice the large number of tiny openings in the epidermis. They are surrounded by two semi-oval-shaped cells. Is there any colouring matter or chlorophyll in any cells that you see? What is its appearance? What shape are the cells of the epidermis? Do they contain chlorophyll?

The minute openings are the breathing pores of the leaf and are called *stomata* (singular, stoma). There are usually thousands to the square inch, especially on the under-side of the leaf. The stomata are opened and closed automatically, by the *guard cells*

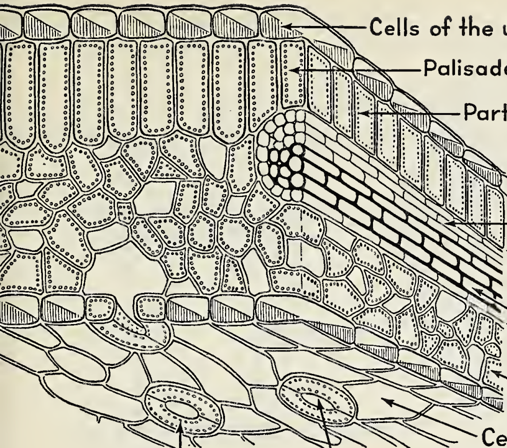


Fig. 33. Diagram illustrating the structure of a leaf. A cross-section, a lengthwise section, and the lower surface are shown.

that surround them, as the requirements of the leaf vary. The guard cells contain chlorophyll—in the minute green particles which you saw under the microscope.

Problem

Use your knowledge of the structure and function of leaves to discuss the factors upon which photosynthesis is dependent, the importance of protecting leaves of crops against plant diseases and insects, watering and irrigation, keeping leaves of plants clean, pruning foliage and branches when transplanting, and shading seedlings after transplanting.

The stem. The leaves and the roots are the workshops of a plant. The stem conveys the raw material or the finished product from one workshop to the other, as the plant requires. Some stems are also storehouses for reserve food supplies. If a stem is examined under a microscope, it will be found to be composed of cells, as are the other parts of the plant. The cells that transport food materials are arranged end to end to form long tubes that run through the stem to and from all parts of the plant. These tubes are grouped into bundles called *fibro-vascular bundles.* In these bundles are also growing cells and cells that strengthen the stem.

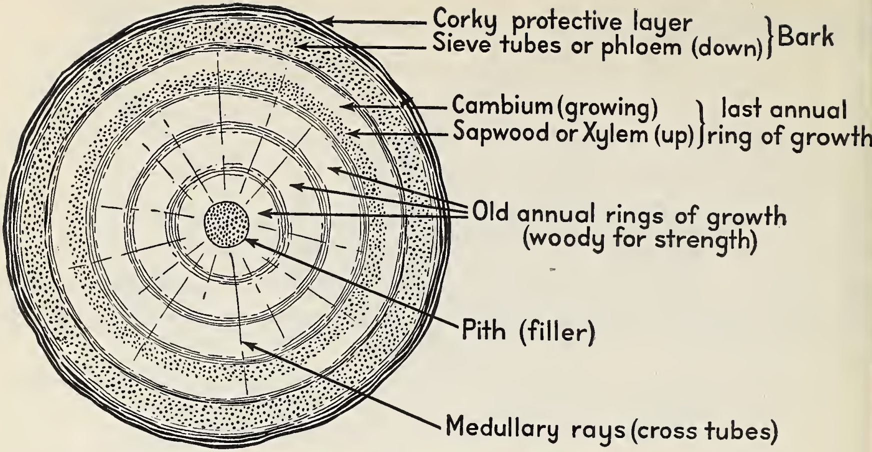


Fig. 34. Diagram to illustrate the parts of the stem of a tree.

Exercises

1. Examine lengthwise and cross-sections of the stem of a sunflower and of a tree. Observe the row of fibro-vascular bundles that extend around the stem of the sunflower. Are there bundles scattered around the pith? The bundles in the tree stem are not as easily located, but it is readily seen that they are arranged in rings. Notice that, as the rings have developed, the pith has been crowded into a small space in the centre. Observe that the old rings around the pith are hard and woody and do little else than strengthen the stem. Examine carefully the last or outside ring. This and the inner bark are the most active parts of the stem. In the green outside part of the last ring are the growing cells; this part of the stem is called the *cambium.* The inside part of the last ring is the *sapwood* and contains the up-tubes that carry raw sap from the roots to the leaves. Peel the bark from the stem or branch of a tree. Notice how loose it is, and how green and moist are the inner part of the bark and the wood just beneath the bark. The green inner-bark is composed of fine passages called *sieve tubes.* These are the down-tubes, which carry manufactured food from the leaves to the lower parts of the plant. The outer corky part of the bark serves to protect the inner parts of the stem. Radiating from the centre of the stem are narrow layers of cells called *medullary rays,* which transport food across the stem.

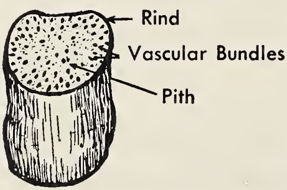


Fig. 35. A piece of corn stalk.

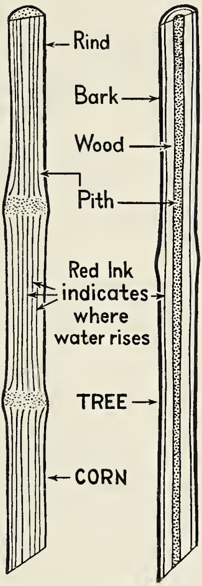


Fig. 36. Left, an experiment to show the rise of water in stems: A corn stem and a tree stem are shown standing in diluted red ink. Right, a drawing to show the part of stems in which water rises.

2. Stand the ends of freshly cut young maple or poplar stems in diluted red ink. After several hours, examine them to determine the parts through which the sap rises.

In the stems of trees, sunflowers, and many other plants, the fibrovascular bundles are arranged in rings. If these plants live for more than a year, the stems increase in diameter by the addition each year of a new ring of growth on the outside of the old rings.

Problem

Show how a knowledge of the structure and function of stems has practical value in grafting and budding; in protection of stems from girdling and such practices as putting light wires around trees or tying horses to tree trunks; in pruning; and in eradication of weeds with underground stems.

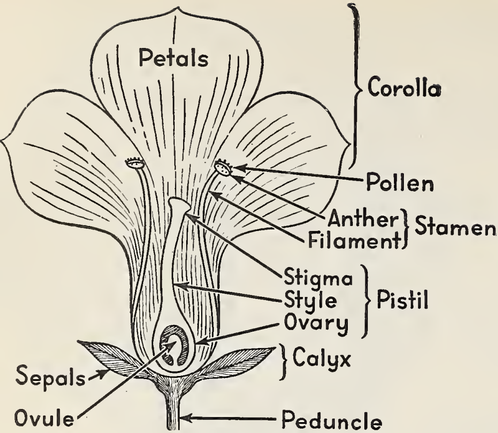


FIG. 37. Diagram to illustrate the parts of a flower.

Flowers. The function of the flower is to produce seed which in turn will reproduce the plant. Not all plants bear flowers, but, if seed is produced, there must be flowers. Perhaps there are plants that you believe have no flowers because you have not seen them. Not all flowers are large and showy. Look for the flowers of grasses and trees in the spring and early summer. The flowers of shade trees appear each spring before the leaves develop. The low-hanging, yellow stamens of the grass flowers are quite conspicuous.

The structure of a flower. The structure of any flower depends upon the plant's method of reproduction.

Exercise

Obtain flowers from the following plants: sweet pea, nasturtium, petunia, and nicotiana. These are suggested because they are large and easily examined. Others should be observed later.

On the outside, just above the stem, will be found the green *calyx*. The divisions of the calyx are called *sepals*. Are they separated or united? The purpose of the calyx is to protect the parts of the flower that produce the seed. The showy, coloured part is the *corolla*. The parts of the corolla are known as *petals*, and, like the sepals, they may be united or separate. Inside the corolla, observe the *stamens*. Count them in each flower. The top of the stamen is the *anther*, which produces the *pollen*. The slender stalk that supports the anther is the *filament*. Look for the *pistil* in the centre of the flower. The head of the pistil is the *stigma*. What do you observe upon touching it? The stalk of the pistil is the *style*, and the lower part is called the *ovary* or seed case.

Cut across the ovary of a large flower. How many compartments do you find? Notice the one or more small white bodies in the ovary. These are *ovules*, which, after pollination and fertiliza-

tion have taken place, develop into seeds. They may be readily seen by carefully removing the stamen tube from around the pistil of the sweet pea and holding the ovary against the light. How many ovules are there in the ovaries of the flowers which you have examined?

Make labelled drawings of these flowers.

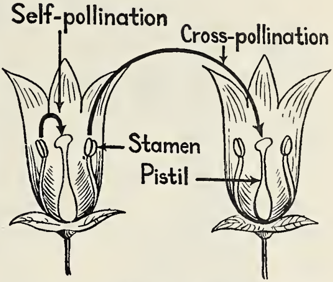


FIG. 38. Diagram illustrating the two types of pollination. Define each.

Pollination. Before the flower can produce seed, the pollen must be transferred from the anther to the stigma. Flowers are assisted in the act of *pollination* chiefly by numerous insects and the wind. Many flowers, such as those of wheat and oats, are *self-pollinated*; that is, the anther pollinates the stigma of the same flower.

Most flowers, however, are *cross-pollinated*—the pollen is transferred from the anther of one flower to the stigma of another flower of the same kind. The staminate and pistillate flowers of the corn are good examples of flowers that are arranged to prevent self-pollination. *Staminate* flowers have no pistils, and *pistillate* flowers lack stamens. Cucumbers, mallows, and squash are examples of plants that have staminate and pistillate flowers.

Exercises

1. Why do some flowers have a brightly coloured corolla or a strong perfume? Suggest a purpose for the sweet, honey-like nectar found in the bottom of the flower-cup, or in the spur of such flowers as the nasturtium. What insects do you observe around flowers? How do they carry pollen from flower to flower? How do the insects profit?

2. The flowers of the grasses and of such trees as the ash, elm, and maple are without bright colours, perfume, or nectar. Do these flowers need these characteristics? How are they pollinated?

3. Flowers are frequently cross-pollinated by man. Suggest reasons for artificial pollination. (See page 164.)

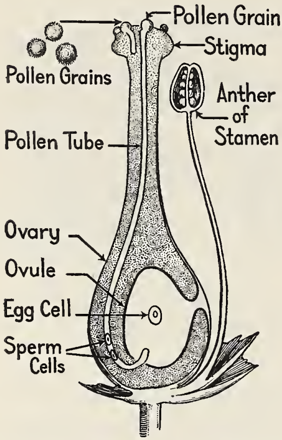


FIG. 39. Diagram to illustrate fertilization in a common flower. When a sperm cell unites with an egg cell, a new individual develops.

Project

Make a study of the methods by which plants encourage cross-pollination. Observe carefully the flowers of such plants as the nasturtium, snapdragon, dandelion, corn, or willows.

Fertilization. After the pollen is caught by the stigma, it produces a microscopic tube, which finds its way down through the style to the ovary. Near the tip of this tiny *pollen tube* there are two minute *sperm cells* or *nuclei*. The ovule encloses another nucleus or *egg cell.* When the pollen tube reaches the ovule, the *sperm nuclei* and the *egg nucleus* unite. The ovule is thus fertilized, after which it develops into a seed. Fertilization can take place only when pollen from the same kind of plant, or one very closely related, falls on the stigma, for example, wheat pollen on a wheat flower.

The fruit. After fertilization, the fruit of the plant gradually takes form.

Exercise

Compare flowers that are faded with fresh ones of the same kind. Stand some sweet peas in water, and observe them carefully as they wither. Which parts die first? Notice the pistil closely. Which parts of it wither away, and which parts grow larger? Give reasons for the changes that occur in the flower.

As the seeds develop, the walls of the ovary expand, and finally a fruit is produced. In its simplest form, the fruit is the ripened ovary and its contents (the seeds). There are two general classes of fruits—*dry* and *fleshy*. The dry fruits are nuts, winged seeds of the maples, grains of wheat, oats, and corn, etc., and pods of

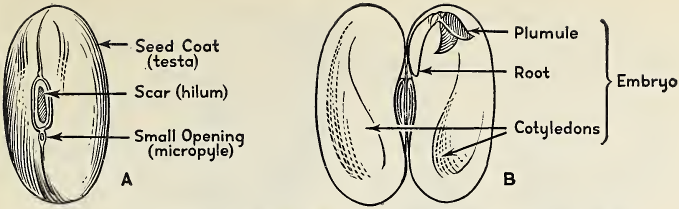


FIG. 40. The parts of a bean seed. A, the outside. B, the inside.

the beans, peas, mustards, turnips, etc. The fleshy fruits include *berries*—oranges, lemons, pumpkins, squash, melons, currants, gooseberries, tomatoes, etc.; *drupes* or stone fruits—peaches, plums, cherries, etc.; *pomes*—apples, pears, etc. Strawberries, raspberries, blackberries, etc., are not true berries, but are fruits of a special nature.

Seeds. A seed is a tiny plant surrounded by a supply of starch and other foods. It is the beginning of the plant and at the same time the ultimate end of all plant activity. Man depends to a very great extent upon the seeds of plants.

The bean seed. By examining a bean seed, much can be learned about the large group to which it belongs.

Exercise

1. Soak some bean seeds overnight; then carefully examine the outside characteristics. Notice the scar, called the *hilum*, where the seed was attached to the pod. Observe in one end of the hilum a tiny opening, the *micropyle*, through which the seed absorbs water.

2. Carefully remove the seed coat or *testa*, and examine the inside parts of the bean. Notice that the seed readily splits into two parts, called *cotyledons* or *seed-leaves*. Between the cotyledons and near one end look for a tiny plant. The minute, leaf-like parts are the *plumule*, which grows into the stem and leaves of the new plant. Below the plumule, observe the *hypocotyl*, below which, as the seed germinates, roots are produced. The plumule, the hypocotyl, and the cotyledons are together known as the *embryo* or *germ* of the seed. The embryo is well fitted to grow into a new plant.

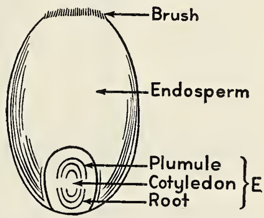


FIG. 41. The parts of a wheat seed. E, the embryo.

3. Drop a little iodine on the cotyledons, and after a few minutes observe the colour that develops. Apply the test for protein outlined on page 255. Suggest a use for the stores of starch, protein, etc., that are found in the cotyledons.

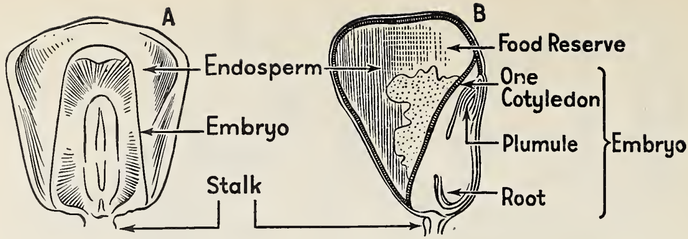


FIG. 42. An external view of a corn kernel (A); a lengthwise section through the corn embryo (B). What is the food reserve for?

Seeds like the bean belong to the class called *dicotyledons* (di, two; cotyledon, seed-leaf).

A kernel of wheat. The wheat seed because of its structure belongs to a second class of seeds.

Exercise

Soak some wheat seeds overnight; then examine them. Observe the embryo at one end of the seed. Look carefully for parts that you can identify as the plumule and the young root. Packed in behind the embryo is a large supply of food, called the *endosperm.* Test the endosperm for starch. Is there an endosperm in dicotyledonous seeds? Notice that between the embryo and the endosperm there is a single cotyledon. The cotyledon absorbs and digests food from the endosperm and carries it to the embryo. (See also Figures 41 and 50.)

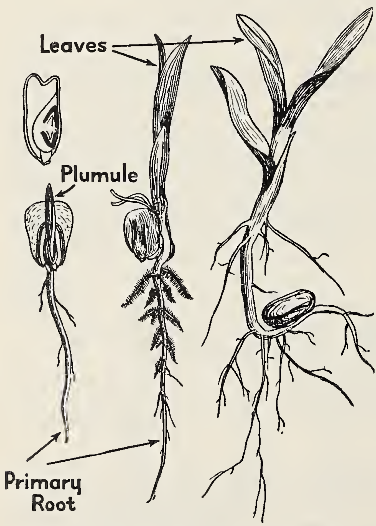


FIG. 43. The germination of corn. How is the plumule protected as it pushes up through the soil?

Seeds with one cotyledon are known as *monocotyledons.* The single cotyledon never appears above the ground, as the cotyledons of some of the dicotyledons do, but remains underground in contact with the endosperm.

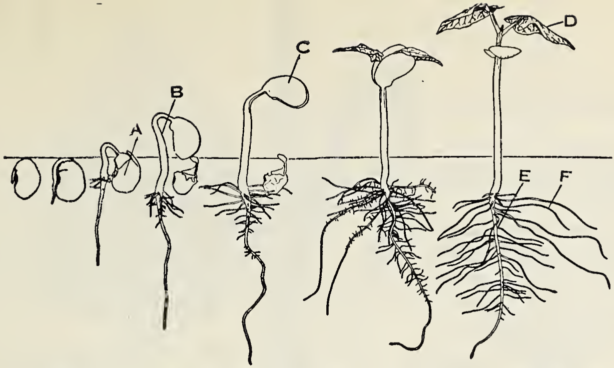


FIG. 44. Stages in the germination of the common bean: A, the seed-coat still retained; B, the binding of the shoot; C, the cotyledon; D, the leaf from the plumule; E, the primary root; F, a secondary root.

Germination of seeds. Under favourable conditions—warmth and moisture—the embryo in the seed awakens, and a new plant is produced. The seed first absorbs water, then swells and breaks the seed-coat. The starch in the seed is changed to sugar, upon which the embryo feeds. The plumule is lifted up to the light, and the root grows downward, producing secondary roots. Soon true foliage leaves develop, and the cotyledons disappear. Germination is not complete until the young seedling is capable of taking care of itself.

Exercises

1. Germinate half a pint or more of seeds in the bottom of a wide-mouthed bottle. Complete the apparatus as in Figure 45. Later, pour in water to force gas to pass through lime-water. Observe closely. The development of a milky appearance in the lime-water indicates that the seeds are producing carbon dioxide.

2. Remove the food supplies of several seeds (the cotyledons of beans and the endosperm of corn or wheat seeds). Plant the embryos along with others from which the food supplies have not been removed. Which grow? Account for the result.

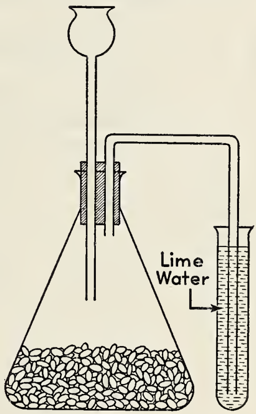


FIG. 45. An experiment to see if seeds produce carbon dioxide during germination.

3. Plant some large and some small seeds of various kinds in a tall jar. Place some of each near the bottom and others at intervals up to within half an inch of the top. Keep the soil moist. Which seeds succeed in germinating and producing new plants from the greatest depth? What seems to be the best depth for the various kinds of seeds that you have under observation? Why can the seedlings from small seeds not reach the surface when the seeds are planted too deep?

4. Plant various kinds of seeds in a box of sand or sawdust. Keep the soil moist. Watch how the different seeds break through the seed coat. Take some up from time to time, and notice how they germinate. Observe the young plants as they appear above the surface. Which seedlings raise the cotyledons above ground? What happens to the cotyledons as the seedlings develop?

Problem

Apply your knowledge of seed structure and germination to such practices as preparation of the seed-bed, early spring planting, control of moisture content of the soil, sowing of seed, etc.

Classification of the plant kingdom. Plants have been classified as shown in the following table:

Classification of the Plant Kingdom

Plant Kingdom	Non-flowering plants	(*a*) Algae, fungi, bacteria	
		(*b*) Mosses	
		(*c*) Ferns, club mosses	
	Flowering plants	(*a*) Plants whose seeds are not enclosed in ovaries; pines, spruces	
		(*b*) Plants whose seeds are enclosed in ovaries	Monocotyledons—Plants whose seeds have one seed leaf
			Dicotyledons—Plants whose seeds have two seed leaves

As you will see from the table, the large class of flowering plants is divided into two main groups—plants whose seeds are not en-

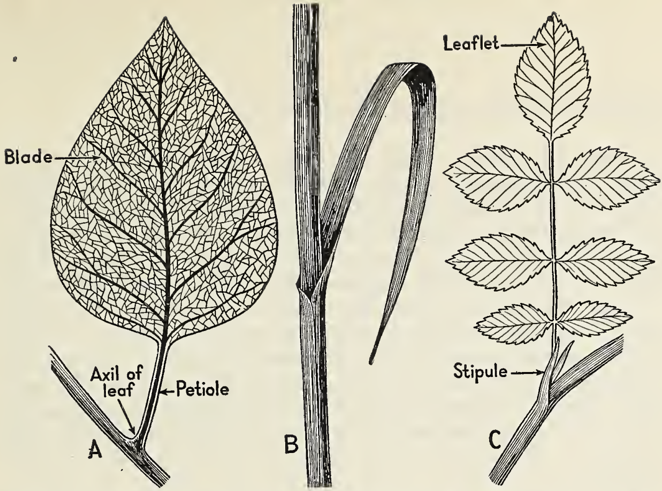


Fig. 46. A is a simple leaf. C is a compound leaf. A is netted-veined. B is parallel-veined. The parts of simple and compound leaves are marked.

closed in ovaries, and plants whose seeds are enclosed in ovaries. Each of these two main groups is again divided into a large number of plant families.

Plant families. The flowers, leaves, seeds, and other parts of the plants in each family closely resemble one another.

Many plant families are exceedingly important agriculturally and to man in general. A better appreciation of later studies of wheat, oats, clover, alfalfa, grass crops, and weeds will result if some consideration is given now, to a few outstanding plant families, several of which are briefly described on the following pages.

Most of the plants with which we are familiar on the farm or in the garden belong to the second main group of flowering plants —their seeds are enclosed in ovaries. All the plants of this group are either monocotyledons or dicotyledons.

The monocotyledons. Plants in this group have the following characteristics in common: one seed-leaf or cotyledon in the seed; parts of flowers in threes; long, slender, parallel-veined leaves; tight bark; and stems in which the wood grows, not in rings, but in scattered bundles. (See Figure 35.)

Gramineae or Grass Family. This is one of the most important plant families of the monocotyledon group. It includes wheat, oats, barley,

rice, and other cereals, the grasses, corn, sugar-cane, millets, and sorghums. The stems are usually hollow and have solid *nodes* or joints. The leaves are alternate, long, slender, parallel-veined, and *sheathe* or wrap themselves around the stem from joint to joint. The flowers are green-coloured, small, perfect (having three stamens and one pistil), and arranged in groups or *spikelets*. Each spikelet consists of a short axis or *rachis*, on which the flowers are supported. Each flower is enclosed in small leaf-like parts called *bracts*. The two lower bracts or *glumes* of each spikelet are empty. The spikelets are arranged in *spikes* (wheat, western rye grass) or *panicles* (oats, brome grass). The fruit is hard and thin-coated (wheat kernels, grass seed). The roots are usually fibrous. Some members of this family have underground stems (brome grass, red top, Kentucky blue grass).

The dicotyledons. Plants in this group are distinguished from the monocotyledons by the following characteristics: dicotyledonous seeds, netted-veined leaves, parts of flowers in fours or fives, bark loose during the growing season, and stems in which the wood grows in rings.

The following are examples of plant families belonging to the dicotyledon group.

Leguminosae or Pea Family. The leaves are *compound* and *stipulate*. The flower resembles the sweet pea, having five irregular petals and usually ten stamens, nine united and the tenth separate; or, less commonly, the stamens may be all joined together or distinct. The seed is contained in one-celled pods or *legumes*. Nodules are found on the roots. The family includes peas, beans, clovers, alfalfas, vetches, caraganas, and loco weeds.

Cruciferae or Mustard Family. The petals and sepals of the flowers are in fours, forming cross-shaped flowers. There are six stamens, four long and two short. The petals are attached below the ovary. The seeds are held in pods divided into two parts. The pods usually break open when ripe. Another characteristic common to this family is a pungent, watery juice. Many of our worst weeds, such as Frenchweed, shepherd's purse, false flax, and all the mustards belong to this family; it also includes radishes, turnips, cauliflowers, cabbages, and cresses.

Rosaceae or Rose Family. The chief distinguishing marks of this family are found in the flowers. They are regular in shape. The

corolla contains five petals. The stamens are numerous and are grouped around one or more pistils. The family consists of herbs, shrubs, and trees, including peach, plum, cherry, apple, pear trees, blackberries, raspberries, strawberries, saskatoons, roses, and similar plants.

Chenopodiaceae or Goosefoot Family. The leaves are thick and coarse. The flowers are minute, dull green, and crumb-like. The seeds are contained in the calyx, which remains around the seed like a paper sack. The family includes beets, mangels, spinach, and some common weeds such as Russian thistle, Russian pigweed, and lamb's quarters. The redroot pigweed does not belong to this family but to one closely related called *Amaranthaceae* or *Amaranth Family.*

Compositae or Daisy Family. This is a large family, including many of our most troublesome weeds. The sunflower is a common example. Make a study of it and discover for yourself the following characteristics. The flowers are arranged in heads and are composed of many small *florets* surrounded by an *involucre* composed of many green, leaf-like bracts. The corollas of the florets are *tubular* or *strap-shaped.* The seeds are tufted and float long distances in the wind. Some members of this family are the thistles, dandelions, asters, daisies, goldenrods, sunflowers, lettuce, salsify, and chicory.

We have considered very briefly only a few of the more common and important plant families of farm and garden. There are some hundred or more classified. Further reference to plant families is made in the section dealing with the identification of weeds on page 177.

Project

Make a study of a few of the more important plant families. Consult references for reliable information. Examine specimens of several members of each family studied. Gramineae and Leguminosae are suggested for your study.

CHAPTER 4

FIELD CROPS

It is nearly 10,000 years since the people of the New Stone Age scratched the ground with sticks and sowed their crops. Ever since that time, crops have played a most important part in the progress of the nations of the world. In Canada, the success or failure of crops touches the life of every person.

Classification of field crops. Field crops are classified according to their use as follows:

Cereals, grasses produced for grain or seed: wheat, oats, barley, rye, corn, and rice.

Forage crops, crops for feeding live stock.

(*a*) Hay crops, fed dried or cured: grasses, legumes, millets, oat sheaves, and corn.

(*b*) Pasture crops, harvested by animals themselves: chiefly the same crops as are used for hay.

(*c*) Soiling or green feed crops, cut green and fed to live stock immediately: corn, or any leafy quick-growing crop.

(*d*) Silage crops, preserved in a silo by the exclusion of air: corn, oats and peas, alfalfa, sweet clover, and sunflowers.

(*e*) Fodder crops: the leaves and stems of threshed grains, legumes, or grasses.

Fibre crops, produced for their fibre: flax for linen, hemp for rope, cotton for cotton.

Oil crops yield oil for many purposes and oil cake for live stock feeding: flax, castor bean, soy-bean, etc.

Sugar crops: sugar-beets and sugar-cane.

Cleaning crops, sown to destroy weeds: intertilled crops, early maturing crops, etc.

Restorative or improvement crops, grown to improve the soil: grasses to restore humus, legumes to restore nitrogen, sweet clover as a green manure, etc.

Cover crops, sown to protect heavy clay and sandy soils from erosion during winter and early spring.

Cereals. Since pre-historic times cereals have furnished man with a very large part of his food supply. In fact, the word *cereal* is derived from Ceres, the name of the ancient Roman goddess who, it was believed, made the crops grow.

Wheat. Wheat is one of Canada's chief sources of wealth. Many millions of bushels, valued at several hundred millions of dollars, are produced annually. Most of this enormous crop is grown upon the western prairies. Because of its great value, it is essential that the quality of our wheat be kept at as high a level as possible.

Canadian wheat is renowned throughout the world for its bread-making qualities. At the International Grain and Hay Show, held each December in Chicago, farmers of Western Canada have been crowned "wheat king" of the world twenty-four times (1950) since the show was inaugurated in 1919.

Canada is the leading wheat exporting country of the world. Much of the wheat grown in many other countries is soft and starchy; but, when it is mixed with the right proportion of Canadian wheat, it produces a good bread-making flour.

> In this chapter, the emphasis should not be on the details of production, such as depth and rates of seeding but rather on the problems involved and the skill required in the growing of crops.

Parts of the wheat plant. The wheat plant will be understood better if each part is examined separately.

Exercises

1. Secure wheat plants for examination. (Note to teachers.—The plants may be gathered in the fall, root and all, and stored for use during the winter. Tie them in a sheaf and suspend them from

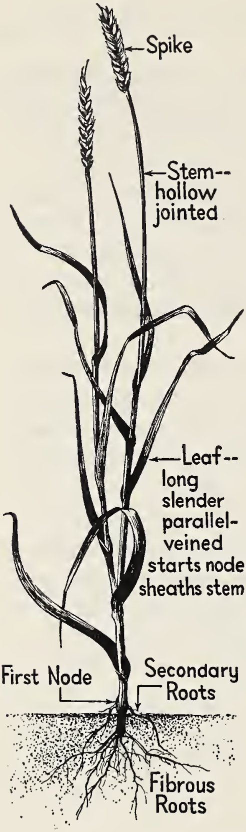


FIG. 47. A typical wheat plant.

the ceiling to protect them from mice.) Briefly summarize the characteristics of each part of the wheat plant as you examine it.

Stem. Is the stem hollow? Notice the joints or nodes at intervals along the stem. Are the nodes hollow? Can you suggest a use for these solid joints in the long, slender, hollow stem?

Root. Are the roots fibrous or tap? Does the wheat root system appear to be dense enough to add humus to the soil? Look for a secondary set of roots springing from the first node of the stem.

Leaf. What shape is the leaf? Are the veins parallel or netted? Where does the leaf start? Notice how the lower part of the leaf wraps or sheathes itself around the stem. How far from the joint from which it grows, does the leaf continue to clasp the stem? Observe how the leaves are arranged along the stem. The wheat leaf is typical of all grass leaves.

Inflorescence. The arrangement of the wheat flowers is known as a spike. The sections of the spike are spikelets. Notice how they are arranged, back to back, alternately along the stalk. Remove several spikelets and examine the stalk that supports them. Observe its zig-zag appearance. It is called the rachis. Do the ends of the spike bear seeds?

Spikelet. How many kernels do you find in each spikelet? Some in the class may find three or even more, but two is the number most commonly found. Notice how each spikelet, even with only two seeds, seems to have had three flowers. When only two kernels are produced, the centre flower was sterile.

Dissect a spikelet. Carefully remove each part in turn, starting at one side of the spikelet. Place all parts as removed on a sheet of paper in the same order as separated from the spikelet. There

should be nine parts, as follows: the outer glume, flowering glume, kernel, and palea of one fertile flower; a sterile flower; the palea, kernel, flowering glume, and outer glume of the other fertile flower.

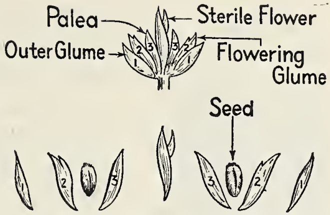


FIG. 48. A spikelet of wheat; above complete; below, the parts separated.

Four-rowed wheat and six-rowed wheat. When each spikelet produces two seeds, there will be two rows of kernels from top to bottom on each side of the spike, or four rows in the whole spike. Three seeds to the spikelet would be three rows on each side of the spike or a total of six rows.

Flower. The wheat flower should be examined early in the summer. It is small and green and consists of the palea and the glumes, three stamens, and one pistil with a broad feathery stigma.

Seeds. Observe the tuft of fine hairs at the top of the kernel. Compare the two sides. One side is deeply creased. The other side is smooth. At the base of the smooth side is found the germ or embryo.

2. Draw the entire wheat plant. Show plainly how the leaves sheathe the stem. Name each part.

3. Make three drawings of a wheat kernel, *i.e.*, crease side, germ side, and cross-section. Name all parts.

4. Wheat belongs to the Gramineae or Grass Family. Refer to the notes on plant families (page 75), and compare the general characteristics of this important family with your observations on the wheat plant. Write a list of the other plants in the family.

The uses of wheat and the influence of climate upon its quality. In Western Canada, the short, hot growing season and the moderate rainfall produce a wheat with a hard, translucent kernel, that has a world-wide reputation for its bread-making qualities. In warm, humid climates wheat ripens slowly and is yellow, soft, and starchy. Such wheats are useful for pastry, breakfast

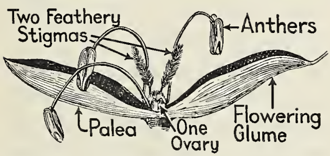


FIG. 49. A wheat flower (much enlarged) enclosed by the palea and the flowering glume. Each spikelet in a head of wheat consists of from three to five flowers, with empty glumes below.

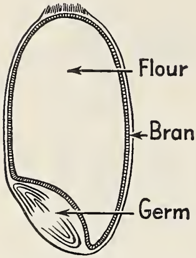


FIG. 50. Diagram illustrating a lengthwise section of a wheat kernel. Of what value is the bran?

foods, and brewing or distilling purposes. Macaroni is produced chiefly from Durum wheat, which, though very hard, produces a poor grade of flour. Low-grade wheat and by-products, such as bran and shorts, are also used for feeding live stock and poultry. What use has wheat in a crop rotation? (See page 34.)

Bread-making quality of wheat. The following exercise will show what factors make Canadian wheat so suitable for bread-making.

Exercise

Moisten some flour to make a stiff ball of dough about the size of an egg. Allow it to stand for half an hour. Then, around the ball tie a cloth to form a small bag. Place the bag in a vessel of water, and work the dough vigorously with the fingers. Change the water at intervals, and continue kneading the dough until the water remains clear.

Into some of the water in which the dough has been washed pour a few drops of iodine. What does the resulting colour indicate?

Upon opening the bag, you will find a soft gummy substance. Try its elasticity by stretching it. It is called *gluten* and is the secret of the bread-making quality of flour. Gluten is a protein. What important plant constituent will it, therefore, contain? Try separating the gluten by chewing wheat.

In the making of bread, yeast is thoroughly kneaded into the dough, which is then put in a warm place to "rise." In the presence of heat and moisture, the yeast plants grow and produce carbon dioxide gas, which forms bubbles or cavities in the dough. When there is gluten in the dough, the walls of the cavities are capable of being stretched. As more carbon dioxide is produced, the cavities grow larger, and the bread rises. If gluten had not made the dough elastic, the walls of the gas pockets would break instead of stretching. The heat of the oven drives out the moisture and the carbon dioxide, and sets the walls of the cavities. Examine a slice of bread.

It will be seen that "strong" flour suitable for making good bread can be produced only from hard wheat containing a high percentage of good quality gluten.

Classification of wheats. There are many classes of wheat, as follows: hard or soft, when classified on a texture basis; red, white, or amber, when colour is considered; spring or winter, when classified according to the time of year sown; Common, Durum, Emmer, Speltz, etc., when classified botanically (most of the wheat produced in Canada is of the Common class, but Durum is also grown); bread or macaroni wheats, when considered from a utility standpoint. For our purpose, we shall consider these classifications collectively.

Varieties of wheat for Western Canada. The varieties of wheat described in the following paragraphs are suited for growth in Western Canada.

FIG. 51. Saunders wheat.*

Exercise

Obtain threshed samples of some Common hard red wheats, such as Marquis, Apex, Thatcher, or Regent; of winter wheat, such as Dawson's Golden Chaff or Kharkov; of Durum wheat, such as Stewart or Pelissier, etc. Examine the berry (kernel), and tabulate your observations as follows:

Variety.
Class: Common or bread, Durum, etc.
Sown: fall, spring.
Shape: long, slender, short, broad, pointed, blunt.
Colour: red, white, light or amber, yellow.
Texture: hard, soft, white and opaque, translucent (test by biting).

*It was announced that 5000 bushels of this new Saunders wheat would be distributed to farmers in Saskatchewan and Alberta in 1948. Was this done? What is its status at present?

The hard, translucent kernels are high in gluten content; the yellow, soft, white berries are starchy and low in gluten.

Marquis, for many years the leading variety in Canada, is now replaced largely by new rust-resistant wheats. It is a cross-bred variety which was produced at the Central Experimental Farm, Ottawa, in 1892. The heads are beardless and do not shatter readily; the kernels are red and hard; the straw is long and strong; the flour is of excellent bread-making quality. Marquis has given good results, but although fairly resistant to most wheat diseases it is very susceptible to stem rust. However, Marquis quality is still the standard (1949). (See section on wheat grades, Chapter 16.)

Fig. 52. Thatcher wheat.

Thatcher is a variety that is highly resistant to stem rust. It was released for distribution in 1934 at the Minnesota Agricultural Experiment Station. The kernels are somewhat small; and the straw is short and strong. Thatcher matures early but has high resistance to after-harvest sprouting, shattering, and loose smut. The flour is equal to that of Marquis in milling quality, although slightly creamier in colour. Thatcher yields well and is widely grown, but because of its lack of leaf rust resistance it is being replaced by varieties such as Regent and Redman in Manitoba and south-eastern Saskatchewan.

Apex, another variety that is highly resistant to stem rust, was developed by Dr. J. B. Harrington at the University of Saskatchewan and released for distribution in 1937. It is a cross-bred wheat and includes among its ancestors Marquis and several rust-resistant varieties. (See Figure 130.) Apex is slightly more resistant to leaf rust and covered smut than is Thatcher.

FIG. 53. Four varieties of wheat, developed by agricultural scientists in their efforts to produce improved wheats to meet the needs of wheat growers of the present. (Photos from Canadian Experimental Farms Branch, Ottawa)

It matures early, yields well, and has good baking qualities. A new Apex, Saskatchewan 2177, has recently been developed.

Rescue wheat was produced recently at the Dominion Experimental Station, Swift Current, to combat the wheat stem sawfly. Its chief feature is its solid stem that does not allow the sawfly larva to pass through it. (See page 226.) Rescue yields better than other varieties under sawfly infestation and in addition has resistance to stem rust. The baking quality of this variety however, is not fully equal to Marquis, and consequently it has not been eligible for top grades. However, the chief cereal inspector made the statement, in March 1948, that it will be graded as 1 N. (See section on wheat grades, Chapter 16.)

Redman wheat has recently been developed by the Dominion Laboratory of Cereal Breeding, Winnipeg, to be used in the rust area of Western Canada (Manitoba and eastern Saskatchewan). It is resistant to stem rust and bunt, and is somewhat more resistant than Regent to leaf rust, loose smut, root-rot, and drought. Redman has high milling and baking qualities.

Regent was produced from a cross including Reward, at the Dominion Rust Research Laboratory, Winnipeg, and was first distributed in 1939. It is highly resistant to both stem and leaf rust, and is less susceptible to covered smut than Thatcher. The baking quality compares well with that of Marquis. Regent is a beardless variety. It ripens in good time.

Reliance which was developed in the United States is a bearded or *awned* variety of wheat with a satisfactory baking quality. It yields well, but is as susceptible to stem rusts and smuts as Marquis.

Winter wheat is grown in large sections of old or southern Ontario, British Columbia, Alberta, and south-western Saskatchewan. It is planted in the fall and harvested the following year.

Winter wheat produces pastry, biscuit, cake, and cracker flours, and to a lesser extent bread flour. It is also a valuable live stock feed. Different varieties of winter wheat are grown in different parts of Canada. Dawson's Golden Chaff has been the principal variety in Ontario, but is beginning to be replaced by others such as Cornell 595. In Alberta, Kharkov and Yoko are most widely distributed, and smaller acreages of Turkey Red and Jones Fife are grown. Yoko is the variety most recommended for the limited winter wheat areas of Saskatchewan.

Durum or Macaroni wheats are a class of bearded, spring wheats, resistant to rust attacks, and suitable for making macaroni, spaghetti, and similar paste products. The kernels are amber-coloured and are usually large. The Durum wheats are more susceptible to smut than Marquis, and are later maturing and less drought-resistant. Mixtures of bread wheat and Durum are highly undesirable.

The leading Durum varieties in Western Canada are Pelissier and Stewart, two varieties that have recently been introduced from the United States. Pelissier and Stewart yield better than other Durum varieties under dry conditions.

NOTE.—Check *annually* regarding recommended varieties. Presently used varieties are constantly being replaced.

Variety zones. In a stretch of country as large as the province of Saskatchewan, for example, soil and climatic conditions vary so greatly that no single variety of wheat can be recommended for general use. Accordingly, the province has been divided into zones, which take into account differences in soil, precipitation, length of growing season, summer temperature, and other factors which affect crop production. It is now possible to recommend for each zone the varieties known to be best suited to that particular area. Students should consult literature published by the Department of Agriculture of their own province in order to secure detailed and reliable information on variety zones.

NOTE.—For information about variety zones and agriculture in general in Saskatchewan, the student is referred to the bulletin *Guide to Farm Practice in Saskatchewan* (see page 37) or to the Agricultural Representative in his locality.

Production of spring wheat. A well drained clay loam, rich in nitrogen and phosphorus, is the type of soil best suited to the growing of spring wheat. Wheat is usually sown as the first and second crops after breaking, summerfallow, or corn. It requires a moderately large supply of moisture. Where wheat is to be sown on stubble, the method and time of cultivation should ensure a liberal quantity of moisture for the growing crop. It has been demonstrated that from thirty to eighty tons of water are necessary to produce one bushel of wheat. In some districts, stubble land and summerfallows are now being prepared for wheat without the use of the plough and the harrow. Such implements as the broad-toothed cultivator or tiller leave the land lumpy and in less danger of drifting. Lighter soil is often packed before or after seeding. What is the practice in your district? (See pages 30 and 33.)

The seed should be pure and of the recommended variety for the district. It should be well cleaned by a fanning mill to remove weed seeds, and germination and smut tests should be made. Your local elevator man may be able to help you to obtain good seed.

Wheat should be sown, at the rate of one to two bushels per acre, as early as soil and weather conditions permit. Early sowing reduces the danger of rust and early fall frosts. The depth at which the seed should be placed, usually two or three inches below the surface, depends on the soil and the season. The seed should be sown deep enough to reach the moisture. Why? Sometimes the land is packed after seeding.

Fig. 54. The development of a wheat plant, showing (1) and (2) the stage of leafing and tillering, (3) in the "shot blade," (4) flowering and fertilization, (5) the filling stage, and (6) ripe. (Photo from *The Grain Growers' Guide*)

Harvesting. Wheat should be cut just before the kernel is ripe—when it is in the stiff dough stage or just hard enough to be dented by the thumb nail. If cut too early, the kernel will shrink, and if the grain becomes too ripe, it may shell badly. It is cut with a binder, tied in medium-sized sheaves, and finally stooked in shocks of eight, ten, or more sheaves. The object of stooking grain is to dry the plant for threshing, and to protect the kernels from the dampness of the ground. As soon as the grain is ready, it should be threshed. A delay in threshing may allow the grain to be damaged by rain or snow. When this occurs, the colour of the berry is often injured, or the grain sprouts. In either case the grade is reduced. If it is not possible to thresh the grain at once, it is often stacked to

protect it. (See Chapter 5, for notes on combines and other harvesting machines.)

Production of fall or winter wheat. Wheat of this type should be sown sufficiently early in the fall to produce a good growth before the frost. Winter killing is due not only to severe winter conditions, but also to failure to build up sufficient food reserves within the crop. The use of phosphate fertilizers has given good results; on certain soils nitrogenous and potash fertilizers are also needed. The application of fertilizer will affect both the yield and the protein content of the crop. In general, the practices followed in producing spring wheat apply also to fall wheat production. It is most important to note that fall or winter wheat yields nearly twice as many bushels per acre on the average as spring wheat.

Oats. In general characteristics, oat plants closely resemble wheat. The inflorescence, however, is a panicle instead of a spike. Figures 48 and 49 also represent oat spikelets and flowers.

Oats are used for feeding live stock, as concentrates or grain feed, hay (green or sheaf feed), or silage. Breakfast foods, such as rolled oats, are manufactured from the kernel. The feeding value of oats depends to a large extent upon the thickness of the hull, which forms from twenty-five to forty per cent of the seed.

In Saskatchewan and many other parts of Canada, Banner and Victory were formerly leading varieties of oats. Both of these have good quality, yield well, and are medium late in maturing. These varieties however, have been largely replaced by earlier and more rust-resistant Ajax, Exeter, and Fortune. Laurel is hulless and is useful for special feeding purposes, such as for young pigs and poultry. Eagle oats were introduced from Sweden and like Laurel are grown in areas in Canada where favourable conditions prevail. Other varieties of oats which are grown to a lesser extent are Valor, Vanguard, Anthony, Cartier, and Erban. New varieties with greater disease resistance are being developed.

Oats grow best in districts where there is an abundant rainfall and where a loose loamy soil predominates. They are sown usually

A B C

Fig. 55. A, Ajax, a new variety of oats. B, heads of six-rowed barley. C, heads of two-rowed barley. (Photos from Cereal Division, Experimental Farms Branch, Ottawa)

after wheat in crop rotations. Seeding is done, at the rate of one and one-half to three bushels per acre, up to about May 20th. The cultural practices outlined for wheat are followed for the most part in the production of oats also.

Barley. Barley is the grain most generally used in Western Canada for fattening live stock. The kernel contains a high percentage of carbohydrates. (See page 256.) This cereal is important as a cleaning crop. Its early maturing qualities make it valuable in preventing such weeds as wild oats from scattering seeds. Barley is also used for malting purposes. O.A.C. 21 was formerly the standard malting barley, but it is now being replaced by Montcalm, which is smooth-awned and a good yielder. Other varieties such as Titan, Olli, Plush, Newal, Prospect, Regal, Rex, Hannchen, Triebi, Colsess, and Warrior are being used chiefly for feeding purposes, depending upon their disease resistance and yielding ability. Watch for the appearance of new varieties.

Fig. 56. Ripe flax. (Photo from *Co-op Grain Quarterly*)

Fall or winter rye. This is a winter annual. It is sown in the fall, and is harvested early the following summer. If sown early, it provides a splendid fall pasture. It is also very useful in preventing soil drifting in the fall and the spring, and is widely grown for that particular purpose in Western Canada. Recommended varieties are Dakold 23 and Prolific.

Flax. Flax seed is the source of linseed oil, which is used in the manufacture of paints, linoleums, and other products. After the oil has been extracted, the remainder of the flax seed is used as oil cake for feeding live stock. Flax is also a valuable fibre crop. In Western Canada, however, it is grown chiefly for seed. It is important to use a variety that is capable of resisting rust and wilt. Recommended flax varieties are: Royal, which was developed at the University of Saskatchewan, and is resistant to wilt and partially resistant to rust and yields well; Redwing, which gives a lower yield than Royal; and Dakota, a new variety highly resistant to both wilt and rust, but slightly lower in yield.

Forage crops. Forage crops are grown to feed live stock. Many plants are valuable for hay; such crops may be cut and dried or cured in the sun, after which they can be preserved for future use. A large number of forage crops are members of the Grass Family. Most perennial grasses add fibre to the soil and have a beneficial effect upon soil structure; they are therefore, extremely valuable in preventing soil erosion by wind and water. The Legume Family also includes many useful forage crops that add

nitrogen to the soil and improve its fertility. Both grasses and legumes are adapted to a wide range of climatic and soil conditions. On many farms where grassland areas are now inadequate, attention should be given to ways of increasing the acreage of grasses and legumes and of improving established native or cultivated pasture areas.

Alfalfa or lucerne. This is a long-lived, perennial pasture oı hay crop of great value. Its characteristics are: root—deep, spreading, tap, frequently producing rootstocks, usually bearing nodules; stem—several branching stems spring from the crown at the head of the root; leaf—compound, three leaflets; flower—small, purple or yellow, resembling a sweet pea, borne in clusters called *racemes;* seed—small, yellow, bean-shaped, produced in curled pods or legumes.

Exercises

1. Secure some alfalfa plants. Failing to find any specimens of alfalfa, carefully uproot several pea or bean plants. Look particularly for the nodules on the roots. The most favourable time to find nodules is at the height of the growing season. (See Figure 10.)

If an alfalfa plant cannot be found, a mental picture of it can be drawn as follows: root like a garden pea, bearing nodules; leaf like a clover; flower like a sweet pea but much smaller; seed like a bean but smaller and yellow. The plants mentioned all belong to the same family and in many parts closely resemble one another. Read the description of this family on page 76.

2. Make descriptive sketches of the characteristic parts of the plant, such as the seed, flower, leaf, and root, showing particularly the nodules.

Alfalfa is a member of the Leguminosae or Legume Family, which includes peas, beans, clovers, caraganas, and vetches. On the roots of these plants are small, irregular-shaped, white lumps called nodules. The nodules are the homes of bacteria that have the power to take nitrogen from the air in the soil. This nitrogen is stored up in the leaves, stems, and roots of the legume. When an alfalfa or clover plant dies, the nitrogen in its body is left in the soil, where it becomes available to plants such as wheat,

oats, grasses, flowers, vegetables, and trees, which cannot use the free nitrogen of the air as the legumes do. (See pages 22 and 23.) In addition to improving the fertility of the soil, the legumes also improve its physical condition. Their deep, penetrating roots open up the soil, facilitating the entrance of air and moisture as well as adding much fibre.

Fig. 57. An alfalfa plant, showing flowers, upper left, pods, upper right, and leaves. (Photo from Dominion Forage Crops Laboratory, Saskatoon)

There are few hay or pasture crops more palatable and nutritious than alfalfa; but unfortunately it frequently produces bloating in live stock. When alfalfa is used as roughage, less grain may be fed, thus reducing the cost of the ration. In a rotation of crops, alfalfa should follow grain or other exhaustive crops. Grimm has been the leading variety, but other varieties, such as Ladak, are replacing it in many areas.

Alfalfa seed is sown in the drier areas early in the spring or late in the fall. In the moister areas, it may be sown with reasonable success as late as June. The rate of seeding is ten pounds per acre. The soil should be well prepared, firm, moist, and free from weeds. Shallow seeding is essential.

In order to establish the right kind of bacteria in the soil, the seed should be inoculated. If the nodule-forming bacteria are not present in large numbers in the soil, the value of alfalfa and other legumes in improving soil fertility is very greatly reduced. There are three common methods of inoculation. The seed may be treated by thoroughly moistening it with a liquid containing the bacteria, after which the seed is dried and sown without delay. Preparations for this purpose are known as nitro-cultures, and may be obtained from the Central Experimental Farm, Ottawa, from most agricultural colleges, and from commercial seed companies. There are different kinds of nodule bacteria. Those that produce nodules on alfalfa and sweet clover are similar and interchangeable; but bacteria from the roots of peas will not

develop on alfalfa, sweet clover, or beans. Nitro-cultures are pure; that is, each contains only the kind of bacteria suited to the particular legume being treated. Inoculation may also be accomplished by spreading over the field to be planted, surface soil in which alfalfa or sweet clover has been growing. This method requires more labour than the culture treatment and is not as satisfactory. A third method is to mix thoroughly, well sifted soil containing bacteria with seed that has been moistened in a solution of sugar or glue or in sweetened skim-milk.

Ordinarily an alfalfa field should not be pastured the first year, nor will it yield much hay, but in the following years yields of one to two and a half tons per acre may be expected and frequently two and sometimes even more crops a year may be harvested.

The crop should be cut when about one-tenth in bloom and before the new shoots are too high. If the second growth is too far advanced, it will be damaged by the mower during the cutting of the first crop. It is important, too, to allow the crop to enter the winter with from eight to ten inches of top growth. As soon as the plants are nicely wilted, they should be raked or piled into small coils or mounds, left loose to ensure a good circulation of air. Good judgment should be used at this time in deciding when the alfalfa is ready to store in loft or stack. If it is put away too damp, it will heat and spoil; but when it is allowed to become too dry, the leaves fall off. The leaves are the most nutritious part of the plant, and great care should be taken to save as much leaf as possible. When alfalfa is grown for seed production, the first growth each year is left to mature.

Exercises

1. Explain why alfalfa is so valuable for feeding young live stock and dairy cows.
2. See problems on soil fertility and legumes, page 37.

Sweet clover. There are two widely used species of sweet clover—the white-flowered and the yellow-flowered. Both are biennials. They may be described in general as follows: root—long, tap, bearing nodules; stems—tall, from about two feet the

first year to five or six feet or more the second, erect, branching; leaf—compound, three leaflets, toothed edge; flower—small, yellow or white according to species, resembles sweet pea, borne in long, loose racemes; seed—small, yellow, hard-coated, bean-shaped, produced in single pods; wild and cultivated.

Exercise

Where sweet clover is grown in the district, specimens should be obtained and examined. Make sketches of characteristic parts, such as a leaf, one flower, a seed, the root showing nodules.

Fig. 58. Sweet clover in bloom. (Photo from Dominion Forage Crops Laboratory, Saskatoon)

Sweet clover is a biennial and a member of the Legume Family. Like alfalfa, it gathers free nitrogen from the air in the soil and stores it up in leaf, stem, and root. It is valuable as a hay and pasture crop and is almost as rich in protein as alfalfa. Because it is a nitrogen gatherer, sweet clover is useful in crop rotation to restore this important plant food to the soil, when it has been reduced or depleted by wheat or some other exhaustive crop. It is also a useful crop on alkali soils.

Arctic, a white-flowered variety of clover, is recommended for Saskatchewan, but other varieties are being introduced. In Ontario common varieties of white or yellow blossom sweet clover are recommended in accordance with the purpose of growing the

crop. Yellow blossom is less coarse and is therefore preferred when the plant is grown for hay. Where intended as a green manuring crop, the white-blossomed varieties are considered more suitable. Sweet clover is sown in the spring on well prepared moist soil. From ten to fifteen pounds of seed per acre are required. The seed is protected by an exceedingly hard covering and will frequently lie in the ground for a year before germinating. In order to hasten the germination, the seed should be *scarified.* This process consists of passing the seed through a machine that scratches or loosens the seed-coat. When the seed has been scarified, a more even germination is secured. The seed should also be inoculated in the same way and for the same purpose as alfalfa seed.

Sweet clover should be pastured very little the first year. The first season's growth is better left to trap the snow for protection during the winter. In the second summer, however, it forms an excellent pasture. It has a peculiar, bitter flavour, and at first most animals find it unpalatable; but, once they have developed a taste for it, they will frequently pass by other feeds to reach it. There is some danger of bloating. Sweet clover should be kept pastured quite close; the older plants become very woody and lose a great deal of their value as a feed for live stock.

Very little hay should be cut from a field of sweet clover the first year. The second year two crops may be harvested; of these the first should be cut early, before the blossoms develop. If cutting is delayed, the stems become woody and coarse, and the second growth is likely to be damaged. It is cut with a mower and coiled. Sweet clover is very difficult to cure. The stems contain a great deal of moisture, which will cause the hay to spoil if it is not very thoroughly dried before being stored. On the other hand, like alfalfa, a great deal of the food value of sweet clover is in the leaves, which very readily drop off if the plants are dried too much.

Other clovers. Alsike and red clovers are useful for mixtures with grasses under certain conditions.

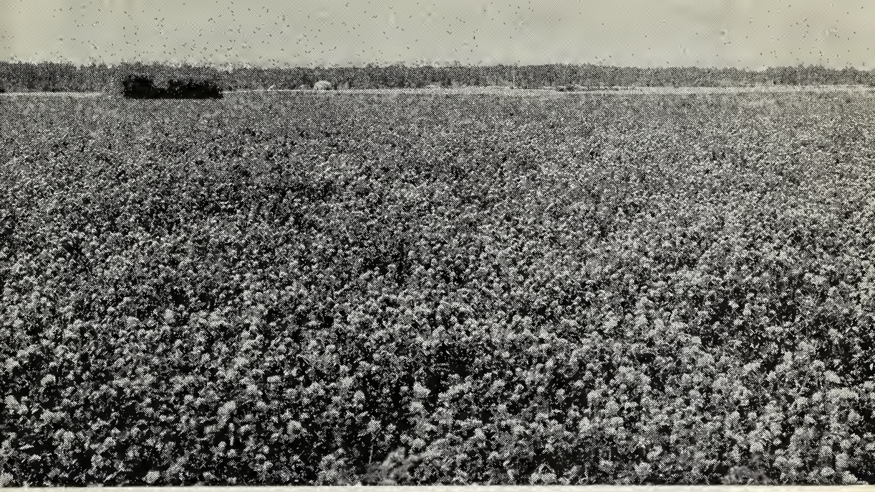


Fig. 59. Red clover in bloom on a farm in Manitoba.

Soy-beans. Soy-beans are bushy legumes which grow to a height of two to three feet. The trifoliate leaves are about the size of the leaves of garden peas, and are usually more or less hairy, as are the pods and stems. The pods are short, each producing two to four black, brown, or yellow beans. The strong roots have many nodules. (See Figure 10.)

The climatic conditions required for this legume are essentially the same as for corn—a long, warm, frost-free growing season and a moderate moisture supply. Ontario, Quebec, and British Columbia provide such conditions. Early maturing varieties do well in Manitoba.

Soy-beans yield oil for a variety of purposes including the manufacture of margarine. The oil cake remaining after the oil is extracted, is a valuable and protein-rich feed for live stock. Soy-beans also have a place under certain conditions as a hay, pasture, or soiling crop. They will produce good silage if mixed with corn. The bean, ground and mixed with other grain, is fed to live stock. When the seed is inoculated, the crop has a beneficial effect upon the soil.

A deep, fertile loam or clay soil is best for soy-beans. It should be well prepared to destroy weeds and to provide a fine seed-bed. Potash and phosphoric fertilizers will stimulate growth.

Fig. 60. Soy-beans as a crop have a wide variety of uses. Illustration shows plants, pods, and beans. (Photo from Manitoba Travel and Publicity Bureau)

The seed should be inoculated and sown in rows twenty-eight to thirty-six inches apart, about the middle of May, at the rate of about forty-five pounds per acre and at a depth of one to two inches. Cultivation between the rows, but just sufficient to control weed growth, is desirable.

Harvesting operations should begin when the seeds are hard in the dry pods and practically all the leaves have fallen. Special care is required in threshing or combining soy-beans to avoid cracking the beans.

Field peas. Peas have proved a highly useful annual legume crop in provinces such as Ontario, Manitoba and Alberta, although in some areas, spread of the pea weevil has seriously limited the growing of the crops. They are a valuable feed for live stock, and in certain areas are an important cash crop, being in demand for the manufacture of soup. When properly inoculated, they have a useful place in crop rotations.

Peas require firm, well drained soil. On cold, wet land, the seed may sour and rot before it germinates. The soil should be clean, as peas do not compete well with weeds.

The seed is sown, between April 15th and May 20th, usually with an ordinary grain drill, two or three inches deep and at the rate of two to three bushels per acre. Care is necessary to avoid injury to the seed. Seed treatment with a mercury dust is desirable to control root-rot. Inoculation with a suitable nitro-culture is also recommended, but this is complicated by the fact that the mercury dust treatment may destroy the effectiveness of the inoculation.

Peas may be harvested with a combine, or, if wind damage is not a hazard, with a mower. Both combine and mower require special pickup guards.

Project

Gather and mount a collection of legumes. Show, if possible, the nodules on the roots of each specimen. (For methods of mounting, see the suggestions made on page 188.)

Slender wheat grass. Slender wheat grass is a deep-rooted perennial. It is a native of Western Canada and can be identified by its long, slender spike or head.

It is a very hardy grass and grows well even in the drier districts. While "western rye grass," as it is commonly called, is splendid for general use, it is better for hay than for pasture, since it is a *bunch* grass and cannot stand being tramped by the stock. Unless it is sown in a mixture with a grass that has spreading underground stems, it is likely to leave bare spots in the field when pastured. Because its root system is not as extensive as the roots of other grasses, it is not as useful for restoring fibre to the soil. Western rye grass is also a favourable breeding place for the sawfly. However, it is a valuable crop for alkali and spring flooding land.

Western rye grass may be sown at the rate of from twelve to fourteen pounds per acre. It has sometimes been the practice to sow grass seed with a nurse crop such as wheat, oats, or barley.

FIG. 61. Left, heads of brome grass, and right, long slender spikes of western rye grass. (Photos from Dominion Forage Crops Laboratory, Saskatoon)

The grain is harvested the first season, and the grass or hay the second and succeeding years. But generally there is insufficient moisture in the soil for the two crops. Usually grasses and legumes should be seeded alone, that is, without a nurse crop. Shallow seeding (one inch or less) in a firm seed-bed is essential. An average yield is from one to one and a half tons per acre.

Western rye grass should be cut as soon as the plants commence to bloom. After this stage, the hay becomes coarse and woody, and loses much of its food value. Soon after it is cut, the grass is raked into rows, then put into small piles or cocks. There it is left until it is thoroughly cured or dried, when it is stacked.

Brome grass. Brome grass is more leafy than western rye grass. It can be distinguished by its loose, open panicle, which develops a purplish tinge as it matures.

Brome is a hardy, long-lived, drought-resistant, pasture and hay grass. It is better for pasture purposes than western rye because of its creeping underground stems. As a crop for adding fibre to the soil, there are few grasses to compare with it. Brome is an excellent grass to use to crowd out weeds, and is also valuable as a sawfly trap. The seed is sown at the same rate and in the same manner as western rye grass. It is also harvested and cured by the same methods. In heavy soils, brome is sometimes hard to

eradicate, but usually a shallow ploughing, followed by frequent cultivation, will completely destroy it. Brome tends to become sod-bound after four or five years, and thus should be cultivated or fertilized with either barnyard manure or a commercial fertilizer.

Other perennial grasses. Timothy is a fairly short-lived perennial grass. It is quite leafy and is a good pasture and hay crop if grown under the right conditions. It is, however, of little value for adding fibre to the soil. Reed canary grass and red top are suitable to low-lying areas. New grasses to withstand spring flooding, etc., are being developed at the Swift Current and other experimental stations.

Forage crop zones. The successful production of a number of the forage crops is difficult in many localities because of lack of moisture, a short growing season, and extremely low winter temperatures. Therefore, care should be exercised in selecting hay and pasture crops for particular areas. Sometimes a mixture, alfalfa and western rye, for example, gives best results. As suggested on page 87, students in each province should consult current literature published by the Department of Agriculture of their own province for authoritative and recent information in this connection.

Crested wheat grass. This hardy, long-lived, perennial grass was introduced into this country from the prairie regions of Russia and Western Siberia. It is very resistant to drought and low temperatures, which characteristics make it admirably suited to the drier plain areas of Western Canada. It is chiefly a bunch grass and has no creeping rootstocks, but has a very dense and extensive root system. The spike or head is more or less fan-shaped or crested. This grass is adapted to a wide range of soils and is ideal for restoring fibre to the soil. It makes good growth very early in the spring, and it is a good fall pasture crop if moisture is available.

Crested wheat grass has proved to be valuable for crowding out weeds. As it withstands tramping and close grazing by live stock and is nutritious and well liked by farm animals, it is a highly

FIG. 62. Crested wheat grass. (Photo from Dominion Forage Crops Laboratory, Saskatoon)

useful pasture crop. It has also been found to do well in lawns around farm homes in the drier localities.

Seed should be sown as early in the spring as possible in well prepared, reasonably clean soil, very shallow, and in general without a nurse crop. When sown for seed, it is planted in rows three feet apart. The crop is harvested for hay purposes as soon as the plants are fully headed out.

Crested wheat grass grows best in cool weather. It will persist for many years, remaining dormant in drier seasons and producing hay or pasture whenever moisture is available.

Grass and legume mixtures. Mixtures of grasses and legumes, such as crested wheat grass and alfalfa, brome and alfalfa, or crested wheat grass, brome grass, and alfalfa are highly recommended. Such mixtures yield better than grass alone over a period of years and produce a better balanced feed. Why? When such mixtures are used, there is less danger of bloating. In addition the hay is more easily cured than when legumes are grown alone.

Pasture management. It is possible for a pasture to become badly run down with a resulting increase in weeds and soil erosion. The chief cause is over-stocking. Pastures that are kept too closely eaten down become less productive and palatable.

In a well managed pasture, each season will conclude with some of the current year's growth remaining. Some of the grass should be allowed to set seed. The application of barnyard manure, five to fifteen tons per acre, will stimulate the growth of the pasture crop. It is a good plan to divide the pasture into smaller areas and to rotate stock from one area to another. Pastures only slightly depleted may be restored by proper grazing practices. Badly depleted areas should be reseeded with a suitable variety of grass. Grasslands are vital in agriculture.

Annual forage crops. In areas where moisture is limited, annual forage crops are more reliable than perennials as sources of hay and pasture. They are also useful to combat destructive insect pests, such as the pale western cutworm.

Oats are superior as an annual hay crop, and produce more and better forage than any of the other suitable crops. Under certain conditions, however, beardless and smooth-awned varieties of barley, fall and spring rye, millet, and even wheat cut before the straw begins to harden, may be used to produce hay. Fall rye is also useful for pasture purposes.

Corn. Corn is a typical grass plant. Examine a specimen carefully to verify this statement. You will find the stem filled with pith but otherwise similar to wheat, oats, and other grasses. Observe that the roots are spread out horizontally and are very near the surface of the ground. This is important to remember when cultivating corn. Deep cultivation destroys many roots.

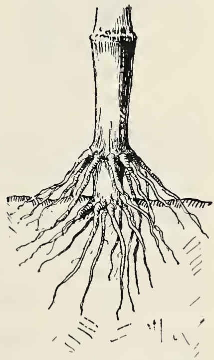


Fig. 63. The fibrous root system of corn. The spreading secondary or prop roots growing from the first node make shallower cultivation necessary as the corn matures.

The flowers of the corn are different from those of any grass that we have yet examined. They are called *unisexual,* because the stamens and the pistils are found in different flowers. The staminate flowers, having stamens but no pistils, are in the tassel. What will be the function of a staminate flower? The pistillate flowers, bearing pistils but no stamens, are produced in the cob. The silk of the corn is the stigma, and the kernel is the ovary. The pistillate flowers receive the pollen necessary for fertilization from the staminate flowers of the tassel. Observe the tassel early in the summer and notice the pollen-covered stamens. Even late in the fall in the dead tassels you will readily find the dried-up stamens. Corn is well fitted for cross-pollination.

Can you name any other plants of field or garden with pistillate and staminate flowers? Why do gardeners transfer pollen from one flower to another in squash and cucumber plants?

To grow corn to full maturity requires a long, hot, and preferably humid growing season. Consequently, in Western Canada, it is grown very little as a grain crop. In provinces such as Ontario, the production of grain corn is increasing. It is used chiefly for feeding live stock and to clean and improve the soil. The thorough cultivation necessary for the production of corn destroys weeds and puts the land in such condition that wheat grown on corn land will frequently equal and sometimes produce a higher yield than that sown on summerfallow. As a substitute for summerfallow, corn cleans and improves the soil and at the same time produces a crop and prevents soil drifting without affecting to any extent the yield of succeeding grain crops. As a forage (feeding) crop, corn is used chiefly as a dry roughage or as silage. It is a very suitable silage crop, being palatable and nutritious, and in Ontario and Quebec it has been heavily relied upon for this purpose for many years. In the extreme southern part of the Province of Ontario, climatic conditions are such that corn can mature for seed quite readily. There is also an increasing demand for corn for the manufacture of such products as starch, syrup, and corn flakes.

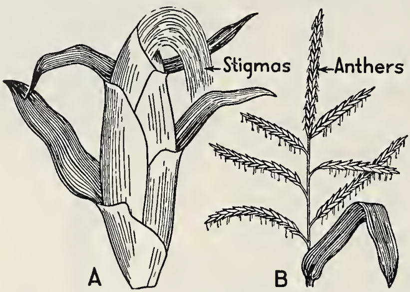


Fig. 64. The flowers of the corn plant. A, the cob, which is a spike composed of pistillate flowers. B, the tassel, which is a group of staminate flowers.

For corn the soil should be thoroughly prepared and manured at the rate of from four to six tons per acre if possible. Seed should be tested for germination. It is sown, usually during the latter half of May, at the rate of twenty to thirty pounds per acre in

FIG. 65. Machines which remove and husk the ears from the standing crop are rapidly becoming the most convenient and economical method of harvesting corn for grain. The illustration shows a compact, light-weight, one-row, pull-type machine, designed for a small to medium acreage of corn. (Photo from International Harvester Company)

Saskatchewan, and ten to fifteen pounds in Ontario. In most parts of Canada it is most commonly planted with an ordinary grain drill, in rows about three feet apart. Cultivation between the rows is essential, but too much or too deep cultivation will damage the shallow, spreading, auxilliary root system.

Corn for fodder should be allowed to grow as long as possible in the fall, but care should be taken to prevent damage by frost. It is harvested, usually early in September, with a grain binder or a corn harvester. If it is to be used as dry roughage, it is cured by stooking it. When stacked alone, care should be taken to have it thoroughly dried to prevent heating. Stacks are often built in alternate layers of corn and dry straw—the straw absorbs excess moisture in the corn. The best way to store corn is as silage. (See page 262.)

Grain corn is harvested when the matured ears are hard and dry. When the crop is to be used for feed, the ears are stored in well ventilated, dry cribs. Corn may also be shelled and stored in bins. Corn intended for seed should be kept particularly dry during storage.

Corn yields have been greatly increased by a method of producing hybrid varieties. Two genetic principles have been employed: (1) Inbreeding tends to intensify characteristics and render the new generation more uniform. Therefore, the first step in the production of hybrid corn is the development of inbred varieties

with desired good qualities. However, inbreeding reduces size and vigour. (2) Cross-breeding tends to produce larger and more vigorous plants. By cross-breeding inbred corn, yields have been increased from around fifteen bushels per acre to 90 or 100 bushels.

Two crosses are made: (1) Inbred varieties are crossed, as, for example, A and B to produce AB, and C and D to produce CD. (2) AB and CD are then crossed to produce the desired hybrid variety. The method followed is to plant one row of the corn selected to be the male parent to from two to four rows of the female parent. The cross is made by removing the tassels of the female rows, which must as a result be pollinated by pollen from the tassels of the male rows.

All hybrid corn is inspected by the federal Department of Agriculture Inspection Service and is registered by the Canadian Seed Growers' Association.

> Students should give chief consideration to the crops that are important in their own province and locality.

Tobacco. Ontario, Quebec, and British Columbia are large producers of tobacco in Canada. Successful tobacco culture requires much technical knowledge and skill.

Flue-cured tobacco, used extensively in cigarette manufacture, is cured in a kiln. Air-cured types include: Burleigh, a heavier, darker tobacco also used for cigarettes; cigar tobacco; and the pipe varieties grown in Quebec. There are also tobaccos used to produce snuff and nicotine insecticides.

In general, tobacco prefers well drained and aerated sandy or light sandy loam. The heavier tobacco soils tend to produce a heavier bodied leaf. The lighter types of soil grow a thinner, more open textured leaf.

The seed is sown during early April in specially prepared beds in greenhouses or canvas covered semi-hotbeds. It is recommended that the soil be sterilized before seeding, using steam under

FIG. 66. Transplanting tobacco plants and applying fertilizer in the same operation. (Photo from Dominion Experimental Station, Delhi, Ont.)

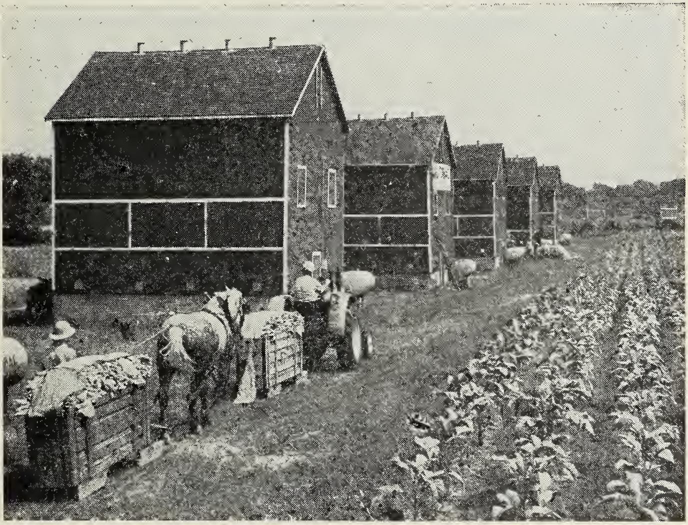


FIG. 67. Tobacco harvest. Boats of tobacco leaves being hauled by tractor and horse to kiln-houses for curing. (Photo from National Film Board)

pressure, to destroy soil-borne diseases, weed seeds, and insect pests. The beds should be kept moist but not wet. The best temperature for germination and growth is from 80° to 88° Fahrenheit. Adequate ventilation is essential at all times. Before transplanting to outdoor locations, the young plants should be hardened for a few days by gradually removing the covers of the beds.

Well in advance of transplanting operations, the soil should be carefully prepared and packed to retain moisture and prevent drifting. Since tobacco soils tend to be low in fertility, fertilizer will be necessary. The present practice is to drill in the fertilizer in narrow bands about four inches on each side of each row of plants.

When the soil is warm and danger of frost is past, the young tobacco plants are set out in outdoor beds in rows about forty inches apart and some eighteen to twenty-four inches apart in the rows. Planting machines are usually employed. Gaps caused by failure of plants to grow should be replanted as soon as possible. Cultivation, progressively shallower as growth progresses, is necessary. When about ten per cent of the flowers have opened, the plants should be topped. This consists of removing the flower heads so that all of the energy of the plant is devoted to the production of leaf rather than seed. Topping results in the development of side shoots or suckers, which should be removed at least twice.

If the best quality of leaf is to result, it is necessary to harvest tobacco at the right stage of maturity and during good weather. One procedure is to split the plants lengthwise to within a few inches of the bottom, after which the plants are cut off close to the ground. Following a brief period of wilting, the plants are hung over laths and hauled to the tobacco barn. From the time the plants are cut until they are placed in the barn, care is required to prevent the leaves being sunburned, bruised, or torn. Flue-cured tobacco leaves are picked off the stems, or *primed,* as each one matures, beginning at the bottom of the plants.

Air-curing of tobacco is more than mere drying, since various chemical changes occur which develop the colour, flavour, and

Fig. 68. Cured tobacco in kiln-house being inspected. (Photo from National Film Board)

aroma of the finished product. The barns should be equipped with ventilators to maintain the correct moisture conditions and temperature over a period of several months. When cured, the leaves are stripped from the plants, sorted, packed into bales of about fifty pounds each, and shipped to processing plants. Flue-curing involves two processes: yellowing and drying. The leaves, tied in bundles and hung over laths, are hauled to kilns where temperatures of 90° to 120° Fahrenheit are maintained for yellowing and ripening and from 120° to 180° for final drying. The leaves are then cooled and hauled to storage barns, where they remain for six to eight weeks, after which they are graded and packed for market.

Sugar-beets. Much of our sugar is now produced from sugar-beets which are long, tapering, silvery-white roots that are about eighteen per cent sugar although the percentage varies considerably from season to season and from area to area. After the sugar is extracted, the residue and molasses beet pulp (a

FIG. 69. The production of sugar-beets was once largely a hand-labour operation. However, steady progress is being made in making modern machinery available for seeding, cultivating, and harvesting the crop. In this illustration, a tractor hauls a loading device along a row of freshly dug beets which are being delivered to the wagon at the left. (Photo from National Film Board)

mixture of beet pulp and molasses) are used extensively for feeding cattle and sheep. Beet tops, cured or as silage, are also fed to live stock.

Sugar-beets favour a deep, well drained clay loam. In Alberta, the land is irrigated. In Manitoba and in Ontario, the growers depend upon the annual rainfall. The seed-bed should be well worked, and should be firm, and level. The application of ammonium phosphate is recommended.

The seed is sown in the month of May. A check drill that spaces the seed at intervals of eighteen inches in rows eighteen inches apart is popular, as such an arrangement makes cross cultivation possible. Another method is to sow the seed in continuous rows and later block out the rows, leaving clusters of plants eighteen inches apart. From the clusters, workers remove all but one strong beet. The seed should be segmented to remove some of the cork which surrounds it, and treated with a mercury dust to prevent black root or damping-off.

Cross cultivation is desirable in order to aerate the soil, break up the surface crust, and prevent "row cracks." Where irrigation is necessary, operations should be timed to prevent the plants from suffering from lack of water at any period of their growth.

Harvesting operations take place in late September. The beets are lifted from the ground and topped. The aim should be to

salvage all of the beets, and to deliver to the local loading station as soon as possible, only fresh, crisp, clean roots.

New developments of promise in the growing of sugar-beets include: breeding varieties with single-germ seeds instead of the present multiple-germ seeds; applying nitrogen and phosphate fertilizer in irrigation water; the production of male-sterile strains of sugar-beets to make possible planting arrangements to produce high quality hybrid seed. Watch for further information.

NOTE.—Every school should have a copy of *Fodder and Pasture Plants*, which is beautifully illustrated in colour, and is for sale by single copies at the office of the King's Printer, Government Printing Bureau, Ottawa, price $1.00.

Be certain of your facts. Watch newspapers and farm magazines for announcements about new and improved varieties of field crops. The student should be sure to consult such publications as *Guide to Farm Practice in Saskatchewan*, *Guide to Crop Production in Ontario*, and other bulletins of the Dominion and provincial Departments of Agriculture for information about varieties recommended from time to time.

Exercises and Projects

1. Make a collection of varieties of field crops. Mount the samples collected with brief, descriptive notes.
2. What, in your opinion, are the problems to be solved in connection with the production of (*a*) wheat, (*b*) other grain crops, (*c*) perennial forage crops, and (*d*) annual forage crops.
3. Compare crested wheat grass, slender wheat grass (western rye grass), and brome grass with respect to value for pasture and hay purposes.
4. Make a survey of your locality to determine the extent to which legumes are grown. Do farmers find it difficult to grow these crops?
5. There are advantages, such as increased yield and nutritive value, in mixing a grass and a legume. Consult suitable publications for information regarding such mixtures.
6. Select for special study and class report one crop that is grown in or near your locality, such as wheat, alfalfa, corn, tobacco, or sugar-beets.

CHAPTER 5

FARM MACHINERY

Because of the ever increasing use of machinery in farming operations, a knowledge of the types of machines available is essential in the study of agriculture. The farmer of today must know the right type of machine to use for a given operation—the wrong machine may do more harm than good. He must also be sure that the machine he decides to use will perform the operation economically—otherwise he may seriously reduce his profits.

The question of power for the farm is also very important. Though there is still a place for horses on many farms (see page 352), more and more farmers are turning to the tractor as a source of power. On many farms electricity is now available and is an economical, convenient source of stationary power for many operations.

Tillage and tillage implements. *Tillage* means the cultivation of the soil for various purposes—to prepare a seed-bed for crops, conserve moisture, open up the soil, or destroy weeds. Tillage also helps to make plant food soluble, and has a good influence on soil temperature. Untimely or excessive tillage, however, may result in pulverizing the soil, thus leading to soil drifting, an increase in insect pests such as cutworms, and a loss of soil moisture. In Western Canada, the cultivation required for weed control is more than enough to secure all the advantages that result from soil tillage. The recommended practice is a "minimum of cultivation, as to both depth and frequency, which will give adequate weed control."

The selection of the right implement is an important factor in good tillage. The more commonly used tillage implements are the moldboard plough, the disk plough, the duckfoot cultivator,

the disk harrow, the drag or spike-tooth harrow, the one-way disk, the rod weeder, the blade weeder, the wire or cable weeder, the roller, and the packer.

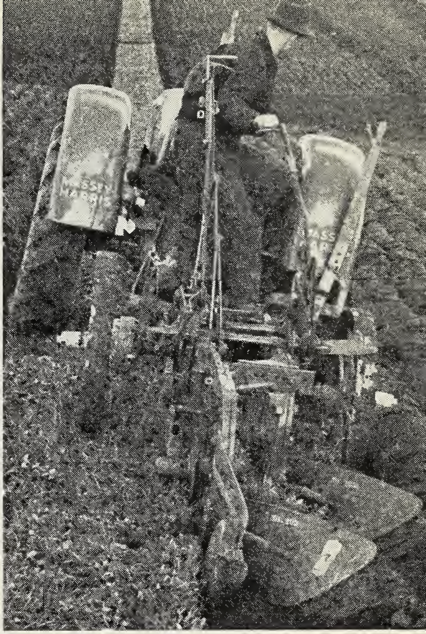


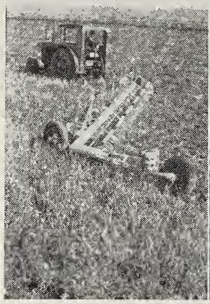
Fig. 70. Ploughing, showing how the moldboard plough turns the furrow slice upside down.

The plough turns the furrow upside down, pulverizes and aerates the soil, and buries stubble and weeds. The moldboard plough used to be considered better than the disk plough in some soils in turning the soil and covering weeds; but it is not now used extensively. When the soil is heavy and sticky, and the moldboard plough will not clean, the disk plough should be used. How are the disks of the latter plough kept clean?

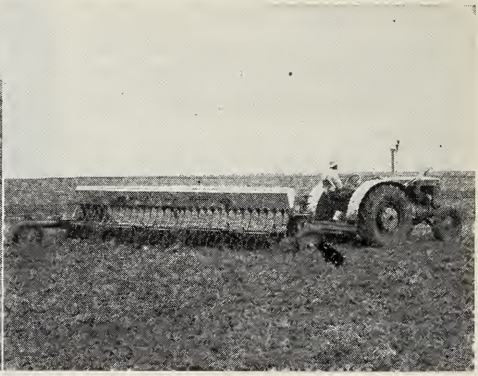
The one-way disk is replacing the disk plough to a considerable extent for preparing stubble land for crops, since it leaves stubble and trash on top of the soil. Like several other tillage machines, this implement may result in serious soil drifting when employed too extensively. The use of rubber tires on the one-way disk has reduced the draft and improved depth control for shallow work. The one-way disk with seeding attachment is designed to cultivate and seed in one operation and is useful for seeding stubble land. The kind of soil should govern the type of disk used and the frequency of use in one season.

The duckfoot cultivator is used to destroy weeds. It leaves the land somewhat ridged and covered with a trash so that soil drifting is reduced.

The disk harrow is also a surface cultivator. It destroys weeds and thus helps to conserve moisture. It is frequently used after the plough to cut up soddy land. It is effective in the fall in



One-way disk harrow



One-way disk harrow with seeder attachment

Double disk harrow

FIG. 71. Three varieties of harrow. Upon what factors does the efficiency of the double disk harrow depend? (Photos from Dominion Experimental Station, Swift Current, and Massey Harris Co.)

FIG. 72. A duplex duckfoot cultivator in operation. (Photo from Massey Harris Co.)

destroying grasshopper eggs and sawfly stubs, and in encouraging the germination of weed seeds. Its efficiency, however, depends upon the sharpness and size of the disks, the angle at which they are cutting, the weight or pressure on the disks, as well as the nature of the weed growth. When it is used in the preparation of summerfallow, there is great danger that it may pulverize the soil too finely and thus encourage drifting. In Eastern Canada, where summerfallowing is little practised and where drifting is less likely to occur, this danger does not exist. The double disk harrow has some advantages over the single disk, but its use is limited to the lighter soils.

The one-way disk harrow is a recently designed tillage implement. Its overall design is patterned after the one-way disk. The type of disks and their arrangement along the frame are very similar to the disk harrow, but all disks are placed so that the movement of the soil from them is in one direction. The one-way disk harrow produces better results than the disk harrow as it leaves the land level rather than ridged. The one-way disk harrow requires considerable adjustment in order to make it operate efficiently. It is inclined to pulverize the soil and, therefore, should not be used too often, especially in the drier areas. Since the width of cut is greater than that of the one-way disk, the one-way disk harrow has won favour on the plains. Seeding attachments placed on disk harrows make it possible to seed large acreages in a short time.

FIG. 73. A spring-tooth cultivator and a spike-tooth harrow being worked over a field. (Photo from International Harvester Co.)

The drag or spike-tooth harrow is employed to close air spaces after ploughing and to destroy young weeds. The flexible type clears better than the other. The excessive use of the drag harrow should be avoided wherever there is any special tendency towards soil drifting. It may also cause the spread of perennial weeds.

The rod weeder is a complementary implement to the duckfoot cultivator and one-way disk. It is helpful in the control of weeds, especially those with long tap roots, which it pulls up. It tends to firm the soil, and thus if used before July 31st, helps to control wireworms. It should not be used for the last cultivation of summerfallow, as it leaves the soil too finely pulverized.

The blade weeder is a great help in controlling soil drifting. It may be equipped with a straight blade or two V-shaped blades. The blades are sharpened so that they cut the roots of weeds and yet do not disturb to any great extent the trash cover on top. It may be used on medium and light soils which are fairly free of stones.

The wire or cable weeder is used for the same field conditions as the rod weeder. In some soils it penetrates more easily and completely.

At times it is advantageous to firm the soil by means of a packer. Two chief types of implements are used—the surface packer and the sub-surface packer. The surface type (crowfoot) packer breaks down the lumps of soil remaining after tillage and seeding

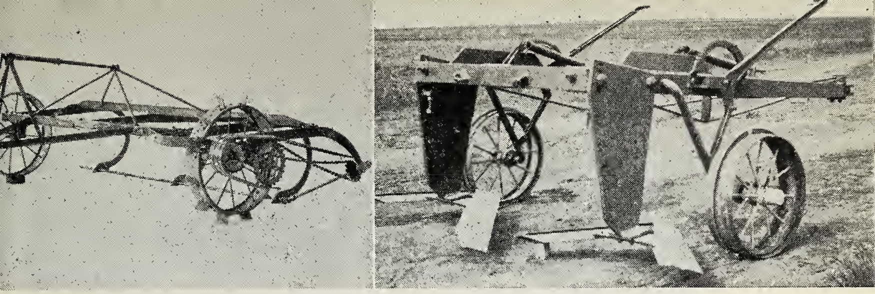


FIG. 74. Left, a rod weeder. Right, a Noble blade cultivator which is a useful tillage implement on lighter soils that are susceptible to wind erosion. (Photos from International Harvester Co., and from Dominion Experimental Station, Swift Current)

operations and leaves the soil ready to drift. It does very little to pack the soil around the seed. The sub-surface packer may be equipped with V-shaped wheels, V-shaped assembled disks, or straight blade disks. It has definite spacings between the wheels or disks and does not break down the lumps. It has more weight concentrated on less surface, and consequently does a better job of packing. The surface packer flattens plant trash left on the surface of the soil, while the sub-surface implement tends to anchor it in an upright position. Where wireworms are causing damage, packing after seeding has value. Packing is more effective if done before the soil is too dry.

Seeding machinery. Planting seed by a drill or seeder has many advantages over the broadcasting method. All types of seeders open a small furrow, drop in the seed, and cover it with soil. The *drills* (rows) opened by a grain drill are usually six inches apart. The depth of the furrow may be regulated and the seed sown at any desired distance below the surface of the ground. The amount of seed sown is controlled by opening or closing the openings through which the seed drops.

Types of drills. The seeder employed should place the seed in the soil at a uniform depth without leaving the land excessively loose. The double disk drill does this and is the one most commonly used in Saskatchewan. In land where there are considerable sods, roots, or trash, the single disk drill gives best results. The press drill is useful on lighter, drier soils where difficulty is experienced in securing early and uniform germination of seed. It also has value in reducing wireworm and, to a

lesser extent, cutworm damage. The shoe drill and the hoe drill have advantages under certain conditions.

Combination tillage-seeding machines have been developed. Fertilizer attachments may be mounted on the drill, and by using them, the seed and the fertilizer may be placed in the soil without becoming mixed, an important factor. As in the case of other farm machinery, various new types of drills and improvements to existing types appear from time to time. The student should consult literature of implement manufacturers, as well as government publications, in order to learn the most recent developments.

Harvesting and threshing machinery. Since the days of the sickle and the scythe, tremendous strides have been made in the methods of harvesting the grain crop. A hundred years ago, much labour was required to harvest even a few acres a day. Now binders and combines cut from thirty to sixty acres in a day's operations.

The binder. With a binder, the grain is cut, thrown upon the table canvas, and carried to the elevator. The elevator canvases raise it to the decks, where it is packed into a sheaf. The needle wraps a length of twine around the bundle, and the ends of the twine are tied by the knotter. The twine is cut by the knife, and the sheaf discharged on to the carrier, where it remains until the operator desires to drop it to the ground. Care must be taken as the sheaf is being formed, to have all the heads of the grain at the top, and the butt end of the bundle as square and flat as possible. Give reasons for these precautions. Power binders have been developed for use with a tractor. The eight-foot horse-drawn and the ten-foot power binder are used in western grain fields.

Threshing machines. The sheaves (except those of malting barley) should be thrown head first into the thresher. They are carried by the feeder canvas to the knives, which cut the twine. From there the grain passes between the teeth of the cylinder and those of the concaves. The cylinder revolves at a high rate of speed, and, as the concaves hold the grain back for an instant,

Fig. 75. The binder, while still in use, is passing from the harvest scene on the larger grain farms. (Photo from Massey Harris Co.)

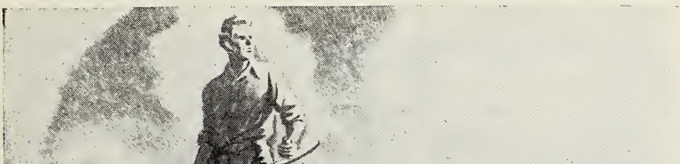


Fig. 76. Great improvement has been made in the machines used on the farm. Over a period of some two hundred years, harvesting operations have been carried on by means of the sickle, the scythe, the cradle (above), the reaper, the binder, and the modern combine (below), each machine representing a definite step forward in efficiency. (Photo from Massey Harris Co.)

the cylinder teeth strip the kernels from the straw. The grain is then separated from the chaff and straw by a fan and a series of sieves. Finally, the grain is elevated, weighed, and run into a wagon or bin, and the blower throws the straw on to the stack. The threshing machine, with ample capacity for the work expected of it, operates more efficiently than a small overloaded machine.

The header and the header barge are machines which are used to harvest short crops, a use almost entirely confined to certain parts of the Prairie Provinces. The crop is cut, then stacked and later threshed by a threshing machine or combine. Well built stacks, constructed to provide a maximum of ventilation and protection from the weather, are essential to preserve the grain until it is threshed.

The combine-harvester. For early maturing varieties of grain that do not shatter readily, many farmers use a combine, which is so called because it cuts and threshes the grain at the same time. The work is performed more quickly and more economically than when these operations are performed separately. The grain should be left standing in the field until the kernels are quite ripe and hard. When grain matures unevenly, is infested with sawflies, or is very weedy, it may be cut with a swather or windrower and left lying on the ground in loose windrows to ripen. As soon as it is dry, it should be picked up and threshed by a combine.

There are three general types of combine: the machine that is towed by a tractor and provided with an engine for operating the cutting and threshing mechanism; the light power take-off driven machine, which is towed and driven by a tractor; and the self-propelled and operated combine, which has its own motor. Good farming practices that will result in the production of clean, early, uniform crops are essential for the economical use of the combine. For harvesting crops that are down or tangled, the machine may be equipped with a special pickup reel or an attachment placed on the cutting bar.

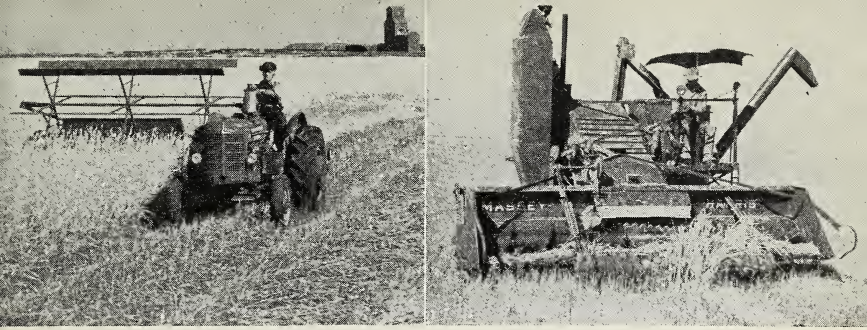


FIG. 77. Left, the windrower is employed to cut crops that are very weedy, unevenly ripened, or have a high moisture content. Right, when the crops are dry, they are picked up and threshed by a combine. (Photos from International Harvester Co., and Dominion Experimental Station, Swift Current)

Haying machinery and equipment. The mower cuts grasses or grains that are not to be tied into bundles, and leaves the crop lying on the ground as cut. There are two types of mower; one type is drawn by horses or tractors; the other is attached to the tractor, and the knife or sickle is driven by a power take-off from the tractor.

To cure the hay crop it is necessary to follow the mower soon with the rake. One type, the bunch rake, gathers the crop in piles or bunches. The other type, the side-delivery rake, delivers the cured hay to one side, leaving it in long windrows.

The hay may be stacked by hand or by a variety of types of power machines. Stacking equipment, however, saves much hard and tedious labour and speeds up the work so that haying may be done in good weather. This improves the quality of the hay, makes better stacks possible, and preserves the quality of the hay while in the stack. For these reasons, it keeps costs lower. In most parts of Eastern Canada, little hay is stacked except in years when yields are unusually large. Thus specialized hay-stacking equipment is rarely found there.

Hay balers have changed. Previously, they were used to bale hay that had been placed in barns, or in large piles or stacks. While some of this is still done, baling hay in the field is becoming increasingly common. Special balers are now provided with a pickup attachment which will pick the hay out of the windrow and bale it in one operation. The bales are bound with wire or

Fig. 78. A power mower cutting into a good stand of hay. This type of mower will cut at least fifty per cent larger acreage per hour than the horse mower. (Photo from Massey Harris Co.)

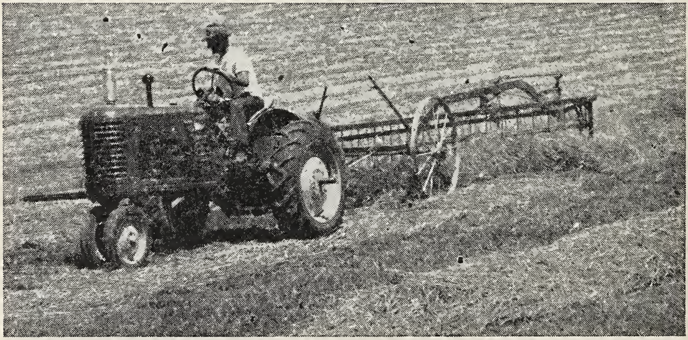


Fig. 79. A side-delivery hay rake may be operated with any type of haying machinery to speed haying operations. (Photo from Massey Harris Co.)

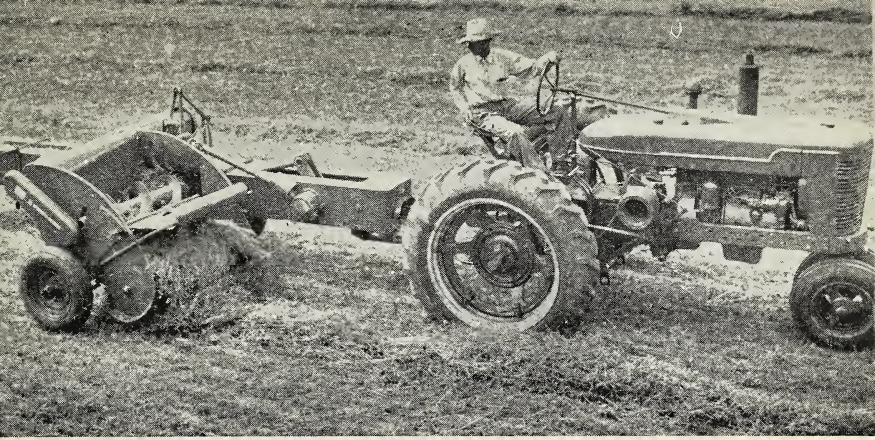


Fig. 80. A light-weight, one-man, automatic-pickup, self-tying, twine hay baler. This machine will produce two to five bales per minute and up to five tons of baled hay per hour. (Photo from International Harvester Co.)

heavy twine. As the bales of hay are bound, they are either loaded on a trailer or dropped to the ground. The bales should not be allowed to remain long in the field, but should be placed in a stack or other storage place. The recent shortage of farm labour has resulted in rapid expansion of this field baling practice since some of these machines can be operated by one man.

Feed cutters are fitted with knives to cut up fodder or hay. One type is stationary, but recently a mobile cutter with a pick-up has been brought into use. The latter picks hay or straw from the windrow, cuts it into short lengths, and elevates it into a wagon or enclosed hay rack. Hammer mills are used to grind hay, straw, or grain by passing them through hammers and screens, the latter varying in size depending upon the job to be done. Grinders of the plate type and crushers of the roller type are also employed to prepare feed for live stock.

Land clearing machines. For clearing land in wooded areas, brush cutters, driven by heavy farm tractors, will cut through poplar and willow brush five to six inches in diameter and larger. After the poles are trimmed they can be piled with a brush piler and tractor, after which the roots can be removed by a root harrow.

The tractor as a source of farm power. Not only has the tractor replaced the horse on many farms, but the tractor itself

has been greatly changed and improved during recent years. Because tractors are expensive, careful consideration should be given to several factors before purchasing one: the kind and amount of work to be done, the nature and topography of the soil, the shape and size of the fields, the type and cost of the fuel, as well as the preference and mechanical ability of the owner or operator.

Rubber tires have replaced extensively the steel wheels with spade lugs that were for so many years standard equipment on farm tractors. These have many advantages. The power at the drawbar has been increased up to thirty per cent, making the small tractor more useful on the farm. Fuel efficiency has been increased twenty per cent or more resulting in a decrease in fuel consumption. Shocks upon the tractor have been decreased and the riding comfort improved. The rubber-tired tractor also raises less dust when in operation. On the other hand, rubber tires are expensive and pack the soil more than steel wheels do. When a rubber-tired tractor is doing belt work, it should be grounded by a chain attached to the frame to prevent the generation of static electricity.

Crawler type tractors have proved to be economical on the farm both for farming operations and construction work. The tractors operate with less slip than other types. They use approximately eleven per cent less fuel than tractors with steel wheels, and pack the land less than any other type of tractor. On rolling land, the crawler tractor has an advantage over both the steel wheel and rubber tire equipped tractor.

The general trend in tractor design is from low to high compression. This increase in compression has increased both horsepower and economy and has made possible the burning of gasoline in place of distillate.

The high compression engine develops more power with less fuel; and it requires fuel that will burn without detonation. Two types of fuel are available: purple, medium-octane gasoline (not leaded), and high-octane, purple gasoline (leaded).

FIG. 81. An hydraulic "farmhand," mounted on a tractor, being employed in stacking alfalfa hay. There are other attachments which may be used to load manure, earth, or snow. (Photo from Dominion Experimental Station, Swift Current)

The medium compression type is not designed with sufficient compression to take advantage of high-octane fuels. Low-octane fuels, such as tractor gasoline and distillate, develop the maximum power without pinging or detonation. Distillate will operate the tractor for less cost than gasoline, but the cost for lubricating oil may be slightly higher. When burning distillate, the engine should be heated up to the correct operating temperature before turning on the distillate.

The diesel engine in a tractor equipped with rubber tires is the most efficient and consequently the most economical. However, the first cost of the diesel is higher, and there should be sufficient work for it to do to pay for the extra cost; it should be used on farms of one section or more. The diesel engine requires a more skilful operator, for unless it is carefully operated and serviced, expensive wear will occur. All tractors operate most efficiently when loaded from three-quarters to full capacity.

Proper care of machinery is essential. Repairs and replacements of farm implements play a large part in increasing costs. On some farms, binders, drills, and other implements are worn out in a few years; on others, the same kind of machinery, doing very similar work, is maintained in good running order for a long period.

All farm implements, when not in use, should be protected from the weather by a machine shed. If there is not an implement shed on the farm, parts of some of the machinery, such as the knotter and the reel of the binder, and rubber belts and tires, should be removed and stored under cover. When rubber tires are left on machines, the load should be lifted from them. Machinery should be protected from live stock and poultry. Polished

surfaces, such as the moldboards of ploughs, and the teeth of cultivators, may be protected from rust by covering them with thick lubricating oil or grease before they are stored for the winter.

During the slack seasons, it is a good plan to overhaul each machine thoroughly and to adjust or replace worn parts. Paint, especially on wooden parts, does much to prolong the life of the implements of the farm. During operation, machinery requires constant attention to keep the various parts tight and in place, and each bearing should be properly and frequently lubricated. In general it may be said that there has been a steady increase in the number and kinds of machines, their average size, and consequently in the total amount of money which a farmer has to invest in machinery. This larger total investment, in turn, is resulting in the development of farms of a larger acreage and also in a rapid growth in custom work, co-operative ownership and operation, and to a limited extent, government ownership and operation.

Exercises

1. The study of farm machinery should be more than a book study. Students should observe machines at work in the fields, gardens, and other parts of the modern farm.
2. What types of tillage machines, and seeding and harvest implements are most common in your area? Ask farmers why they are operating the types of machines you find most commonly used.
3. Prepare a list of recent machines and explain in what respects each is an improvement over preceding machines of the same type.
4. What factors should be considered when purchasing the following machines: grain drill or seeder, diesel tractor, plough?
5. What implements should be used to eradicate such perennial weeds as Canada thistle and leafy spurge; to combat such insects as wireworms and sawflies?
6. New types of machines are continually being introduced. Visit the machinery displays at implement dealers and at agricultural fairs in order to keep posted regarding the latest developments.

CHAPTER 6

THE VEGETABLE GARDEN AND ORCHARD

A vegetable garden that can be cared for with a minimum expenditure of time and energy, may be a source of great satisfaction and no little profit, for it can be made to supply an abundance and a variety of vegetables for the entire year. A farm orchard, also, is no longer considered a very difficult undertaking on the prairies; it has been found that many fruits can be successfully grown there. In Eastern Canada, the farm garden may be said to be the rule. On the other hand the farm orchard has tended to disappear in many areas in Eastern Canada to be replaced by the large orchards of the specialized fruit growers.

The location of the garden. The location of the garden is an important factor in ensuring its success. Its protection from the wind, one of the worst enemies of successful gardening, may be accomplished by means of a dense shelter belt of trees and shrubs. The trees should not be too close to the garden, however, because their roots rob the garden soil of moisture and plant food, and their tops shut out too much sunlight. Locations subject to early fall or late spring frosts are not good. Where such danger exists, a site somewhat higher than adjoining areas will provide for good air drainage and thus reduce the risk of frosts. The vegetable garden should be situated as near as possible to the house, where most of the produce is used.

Preparation of the soil. A deep, rich loam, that has been heavily manured twelve to fifteen tons per acre and thoroughly prepared, will give the best results. The soil should be well drained and free from alkali. Heavy clay soils or extremely sandy soils are not desirable, but in most cases either can be made suitable by a heavy application of well rotted manure; and the addition of pulverized limestone, or wood or soft coal ashes

Fig. 82. A flourishing farm garden is not only a source of revenue for the owner, but also adds greatly to the attractive appearance of his home. (Photo from Saskatchewan Department of Agriculture)

will help to reduce the tendency of clay soils to bake. The seeds of many garden crops are very small, and for this reason a finely pulverized seed-bed is necessary. State other reasons for this. When ploughing or spading is done in the fall, it helps to control harmful insects and usually produces more satisfactory results than when left until spring. But whether fall or spring cultivation is practised, should depend very largely upon local soil and climatic conditions. In drier areas, one half the garden space should be summerfallowed unless irrigation is possible.

As outlined on page 24, it is becoming more and more important for gardeners and farmers to know that their soils have the correct nutrients to produce plants rich in minerals and vitamins. Otherwise, they may be producing food that is actually deficient in essential health promoting elements.

The compost heap. An excellent supply of organic matter for the garden soil may be prepared by piling the waste stems and leaves of the garden, and the grass mowed from the lawn, in layers, six or eight inches deep, alternating with one or two inches of soil. If the heap is kept moist and forked over once or twice in the fall and again early in the spring, the plant material in it will readily decay. The pile will be more likely to remain damp if the top is flat and the sides are perpendicular. In the spring, the compost heap can be spread over the garden like ma-

nure and thoroughly spaded into the soil. Diseased plants or weeds bearing ripe seeds should not be thrown on the pile. Why?

Arrangement of the crops. The farm garden should be planned so that horse labour or small motorized equipment can be used as much as possible. For this reason the crops should be sown in long, straight rows; if necessary, more than one kind of crop should be planted in each row. The rows should be uniformly spaced, with the exception of those containing squash, citron, etc., or permanent crops, such as rhubarb and asparagus. This arrangement makes it possible to cultivate the garden with one adjustment in the width of the cultivator teeth. Even in city gardens, long, uniformly spaced rows will save a great deal of time, especially if a wheel hoe is used. In drier areas, rows spaced farther apart will help to ensure a better moisture supply for each plant. If irrigation is planned, the rows should be planted in the direction of the slope; or, if there is danger of the flow of water causing erosion, on the contour. Perennials, such as rhubarb, asparagus, and the small fruits, should be placed by themselves in one part of the garden. Early maturing crops, such as lettuce and radishes, may be sown between the rows of cabbages, squash, melons, or other late maturing crops. An arrangement of early and late crops is useful where space is limited.

Selection of the seed. A selection of crops should be made so that the garden will supply vegetables during the entire growing season and for winter use. Varieties should be chosen that have proved to be suitable for the district. The reports of the Dominion Experimental Farms are very useful as references in this connection. Copies of such bulletins as *The Prairie Farmer's Vegetable Garden* may be obtained free by applying to the Publicity and Extension Branch, Department of Agriculture, Ottawa. In Saskatchewan, the latest issue of *Guide to Farm Practice in Saskatchewan* is a good reference. Western-grown seed will produce the best crops in the West, and should be ordered from seed houses in Western Canada, except where special varieties are desired.

Planting the garden. The garden is most easily planted with a hand or horse drill. Small seeds, such as lettuce, should not be sown more than a half or three-quarters of an inch deep, but larger seeds, like the peas and beans, can be placed at a depth of two or two and a half inches. It is important that the seeds touch moist soil, but the finer seeds especially, should not be planted too deeply. The soil placed over the seed should be tramped or packed after planting. Give two reasons for this. One authority has outlined the following planting guide:

"Varieties to be sown early in the spring: beets, carrots, lettuce, onions, parsnips, peas, radishes, kohl-rabi, garden cress, salsify, spinach, parsley, and leeks. Seeds sown in hotbeds, but plants will stand some frost: cabbage, cauliflower, and celery. Varieties to be sown after the danger of frost is over unless protected: beans, corn, cucumbers, melons, potatoes, and squash. Seed sown in hotbeds, but plants will not stand frost: melons, tomatoes, egg-plants, and peppers. Swede turnips should be sown late, though turnips will stand frost."

Hotbeds and cold frames. The hotbed should be located where it is exposed to a maximum of sunshine and at the same time protected from cold winds. It may be built on top or partly below the surface of the ground. If the latter method is followed, a hole, about one and a half feet deep and about one yard wider and longer than the frame, is prepared. Fresh heating horse manure, fairly free from straw, is used as the source of heat. It should be piled near the location of the hotbed until it begins to heat. When this occurs, the pile should be forked over once to ensure more uniform heating. Five or six days later, the manure should be ready for the hotbed. From one to two and a half feet of it is placed in the pit. The quantity of manure required depends upon the time that the hotbed is prepared, less being necessary for a start late in March than for an earlier beginning. The manure should be placed in the pit in layers, and each layer thoroughly tramped. The frame is then placed on the manure, and more manure is banked around the outside. A

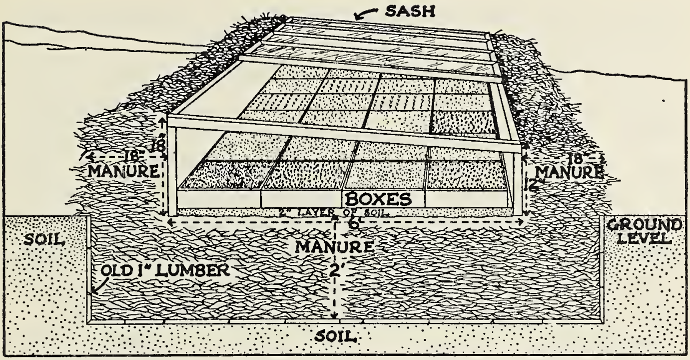


Fig. 83. Plan of a hotbed with one end of the frame removed to show the structure. (Drawing from Extension Department, University of Saskatchewan)

layer of about six inches of rich sandy soil is next thrown over the manure in the frame. After the sash is in place, it is necessary to wait for a few days before sowing seed, to allow the temperature to become regular. A temperature of from 68° to 90° Fahrenheit should be maintained by raising or lowering the sash as necessary. When the proper heat is obtained, the soil requires stirring up, and the surface should be made fine and level to receive the seeds.

The essentials in the management of a hotbed are adequate ventilation, light, moisture, heat, and protection from cold winds. Plants should be very carefully protected from chilling drafts, and should not be watered too heavily, as these conditions cause them to damp-off. (See page 205.) Ventilation may be controlled by raising and lowering the sash. As the warmer weather approaches, the sash may be raised for longer periods each day in order to harden the plants for transplanting to the garden. Suggestions about thinning, transplanting, and hardening are discussed at greater length in later sections of this chapter.

The cold frame is similar to the hotbed, except that no manure is required. It is often used to receive plants transplanted from the hotbed before it is time to put them out in the garden. Some

gardeners prefer to cover their cold frames with factory cotton instead of glass.

Starting plants indoors. It is possible to start a good supply of plants early by sowing the seed in shallow boxes placed in a window with a sunny exposure. When sufficient space is available, this method eliminates the trouble of preparing and caring for a hotbed. Plants may also be started indoors in this way and transplanted later to a hotbed or cold frame. For example, tomatoes may be sown indoors about March 1st and transplanted in early April to a hotbed. This saves an early start with the hotbed, and also produces large, hardy plants for setting out.

Prepare wooden boxes of convenient size and shape and from two and a half to three inches deep. Bore a number of holes in the bottom for drainage. Use a sandy loam into which some fine, well rotted manure has been thoroughly mixed. Sift the soil to remove coarse lumps and fibre. Fill the boxes or "flats" to within three-quarters of an inch of the top. Press lightly with a piece of board to make the soil fairly compact. The soil should be damp, but not wet.

Planting should be done, as a rule, between March 15th and April 10th. Sow the seed carefully and not too thickly. Cover seeds lightly by sifting soil over them. The seeds should not be covered too deeply; the very small seeds should be barely covered with fine soil. Water them well, using a very fine sprinkler if possible; or cover the seeds with a cotton cloth, and carefully pour the water on the cloth. Keep the soil moist by daily sprinkling. Place the box in a window or a hotbed where it will be warm. A sprinkle of sand over the surface will help to prevent damping-off, a disease which results from keeping the soil too wet on top. The sand will dry out quickly and prevent the damping-off bacteria from multiplying. Once the plants become established, watering should be less frequent. A piece of glass or several thicknesses of newpaper will help to prevent soil in boxes placed in windows from drying out. Any covering should be removed as soon as the seeds are well germinated.

Transplanting. Most plants that have been started early indoors or in a hotbed are improved by transplanting once or twice before they are set out in the garden. The first transplanting should take place when the plants have produced their first or second pair of permanent leaves and are about two inches high. They are replanted about two inches apart in other boxes or in another hotbed if necessary. A round stick, about six inches long and somewhat pointed, is useful for making the holes in the soil into which the small seedlings are dropped. The roots are covered by lightly pressing the soil toward them with the

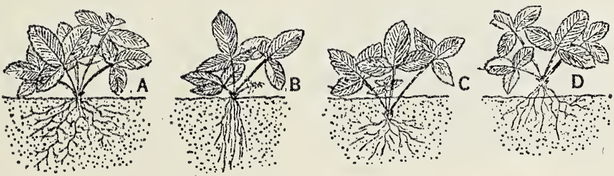


Fig. 84. The right and wrong way to set out plants. A is placed at the proper depth and with roots well spread. What is wrong with the way in which plants B, C, and D are set out?

fingers. Be careful not to bruise the tender stems. Water carefully at once to settle the soil. Shade the young plants from strong sunlight for two or three days. Water the soil thoroughly each morning.

If the plants grow sufficiently to require moving again before it is time to set them out, they should be transplanted in the same manner as before, this time leaving more space between them.

As much soil as possible must be kept around the roots when the plants are being lifted during the transplanting process. Every precaution should be taken to prevent the roots from drying out; and the roots of each plant should be spread out as much as possible. After the soil has been replaced around the roots, it should be well watered. This helps to make the soil compact and to work it in around the roots. The soil should not be tramped or otherwise packed while it is water-soaked. Why?

Hardening plants. The final transplanting from hotbed to garden is usually done about June 1st, leaving such tender plants as tomatoes until the last. It is necessary to harden the plants before removing them from the hotbed. This is accomplished by raising the sash a little each day, gradually removing it altogether for short intervals, and then all day, and finally leaving the plants entirely uncovered unless frost threatens. The newly set out plants should be shaded from the direct rays of the sun, and the more tender plants, particularly tomatoes, should be protected from the whipping of the wind. For this purpose, tin cans with both ends cut out may be used for the smaller plants. Protection for the larger plants may be provided by three or four shingles, thin boards such as are used in fruit crates, or boxes with the top and the bottom removed. An evening or a cloudy day is the most suitable time for setting out plants. Never transplant seedlings showing any signs of disease.

Summer use for the hotbed. After the plants have been removed to the garden, the hotbed frame, without the sash, may be used to produce squash, tomatoes, or other crops that require a very rich soil and a hot protected location.

Thinning. Plants growing too close to one another become weak-rooted, tall, and spindly. To prevent this, plants that are started from seed sown directly in the garden usually require thinning. This should be started when they are about an inch or two high and continued regularly as growth progresses. For healthy development the leaves of one plant should just touch those of its neighbours. Frequently when carrots, beets, etc., require thinning, the young plants pulled up can be used on the table.

The management of the garden. The garden should be fenced and kept free from plant refuse at all times. A clean garden, free from all unnecessary growth, will help to control insects and diseases that damage the crops. (See Chapters 8, 9, and 10 for methods of controlling weeds, plant diseases, and insect pests.)

When the garden is watered, it should be done thoroughly. Soaking a small part at a time, if necessary, taking several days

to cover the whole garden, is much more satisfactory than sprinkling the surface lightly every day. Once the plants are well rooted, the best results are secured by opening small trenches between alternate rows or at intervals of from four to six feet, and running water slowly into each trench for an hour or so according to its length. After the water has been turned off and the soil around has become dry enough, the trench should be covered with dry soil. Many dry land farmers are now irrigating their vegetable gardens, using water from farm dugouts or dams. For this the furrow system is recommended. One authority states, "The ideal method is to allow a small trickle of water to run down the furrow for a sufficient number of hours to thoroughly wet the space on which the plants are growing without the water actually touching the plants." The soil should be thoroughly wet to a depth of at least eighteen inches or two feet underneath the plants.

Fig. 85. A field of beans planted on the contour. There was no soil erosion during the planting and growing seasons. (Photo from U. S. Soil Conservation Service)

Whether under dry land farming or other conditions, the greater part of the garden should be manured each year with well rotted manure, which in most cases is best dug into the soil in the fall. Commercial fertilizers (see page 26) are usually not necessary for gardens on the prairies except in special circumstances. Certain fertilizers, however, have been found to be useful in accelerating growth in young plants and increasing yields. Frequent cultivation also is required to produce good crops. Why?

Crop rotations. The most successful gardeners practise a well planned system of crop rotation. Deep-rooted crops, such as beets and carrots, should be followed by crops like peas and beans; wide spreading melon, squash, or cucumber vines are a change from closely planted crops. Tomatoes and corn have a different effect upon the soil from the common vegetables and therefore, have a place in crop rotations. A crop rotation helps to control plant diseases and injurious insects, as the pests that attack one crop do not, in most cases, damage other crops. Kindred crops, such as cabbage and turnips, should not be grown in succession as some diseases affect both. In most cases, long rotations are advisable.

Exercise

Plan a crop rotation for a medium sized garden. Include a few permanent crops, such as rhubarb or small fruits. Submit your plan to a gardener for approval.

NOTE.—A good reference is *Irrigating a Prairie Farm Garden*, Publication 657, Department of Agriculture, Ottawa.

Gardening tools. Tools that will perform the necessary work with the least expenditure of labour and time should be selected for gardening. The farm garden should be planned to permit the use of a horse-drawn or motorized cultivator or scuffler, and for the same work in the city garden, a wheel hoe is recommended. A strong spading fork, a steel rake, and an ordinary hoe are necessary. A Dutch or push hoe is the best type, as it leaves the surface of the soil smoother than the ordinary hoe and is not as tiring to use. A trowel, a weeder, and other small tools are useful but not essential. A convenient tool for opening the ground when transplanting small plants, is a dibble, which may be simply a sharpened stick or the pointed handle of an old spade.

Harvesting vegetables. The proper time to harvest vegetables depends chiefly upon their maturity and the way they are to be used. Peas and beans should be gathered young and fresh for serving green, or well ripened if the seed is the product desired. Beets and carrots may be pulled and used from the time they

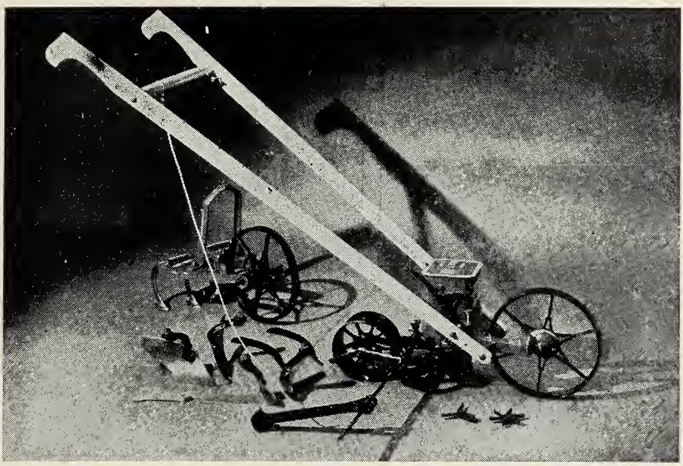


FIG. 86. A combination seeder and wheel hoe. The seeder attachment can be removed and the small plough or the cultivator teeth fixed in place in a few minutes. (Photo from S. L. Allen & Co. Inc.)

need thinning until they are harvested in the fall. Cabbage is ready for use as soon as a large solid head is formed. Tomatoes are picked green for pickling, or left on the vines to ripen if they are for table use. Late tomatoes may be gathered green and ripened in a warm, sunny window, or they may be stored in a cool, dark place and brought out to the window a few at a time as required. By this method tomatoes may be provided for the table late in the year. Onions are pulled and left on the top of the ground for a few days to dry, being covered at night for protection from frost. Mud-covered root or tuber crops are undesirable, and therefore, should be harvested when the soil is dry and crumbly. It is necessary to protect tomatoes, cucumbers, and other tender vegetables from early fall frosts. Vegetables such as cabbages, turnips, etc., will stand some frost but should not be exposed to heavy freezing.

Storing vegetables. When placed in storage, vegetables should be clean, sound, dry, and free from insect damage. They may be

stored in cellars, pits, or root-houses, but the storehouse should be dark, cool, moderately damp, well ventilated, and protected from frost. If the store-room is exceedingly dry, too much moisture will evaporate from the vegetables; on the other hand, poor ventilation and too much moisture cause decay. (See Figure 87.)

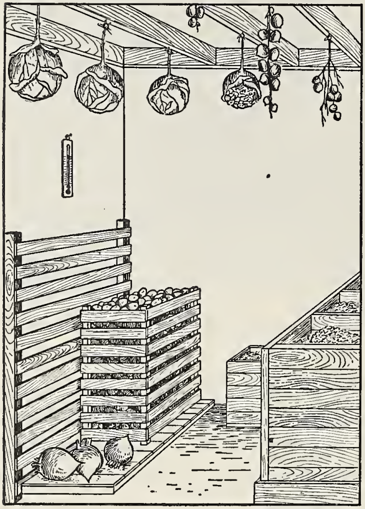


Fig. 87. A well-planned storage room. What provision is made for storing the various kinds of vegetables?

Onions should be placed on slatted shelves to provide a good circulation of air around them. The outside leaves should be stripped from cabbages and cauliflower, which are best stored hung by the stem-end from the ceiling. Why? Carrots, beets, and other small roots are usually stored in boxes of sand to prevent them from becoming dry and soft. It may be necessary to add water occasionally to keep the sand slightly moist, but this will depend on the humidity of the air in the storage room. Potatoes should be piled on a false floor and against slatted walls to ensure a circulation of air, and should be sorted over from time to time to remove decayed tubers and to break off sprouts. A hormone dust is now available to stop sprouting which is effective even if storage temperature is too high. It is applied as the potatoes are being placed in the bin. It should not be applied to potatoes to be used for seed. All of these vegetables should be kept at a temperature just above freezing.

Root crops and potatoes may be stored all winter in pits. The pit should be deep enough to have the top of its contents below the surface of the ground. After the pit is filled, a few boards or

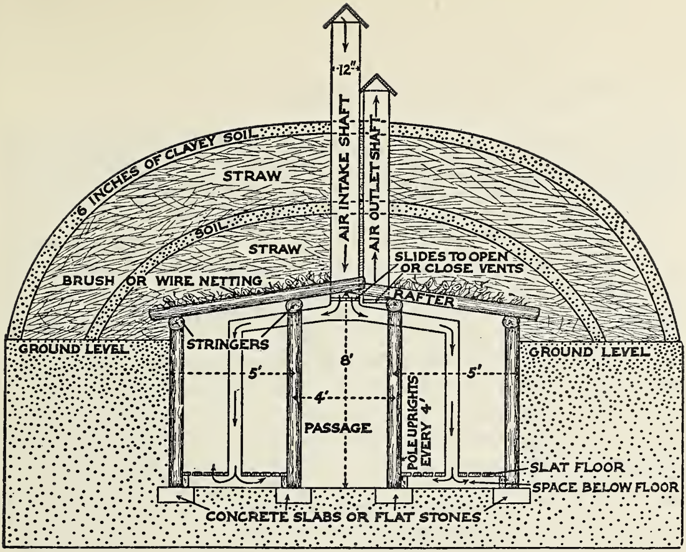


FIG. 88. An outdoor vegetable storage room. The excavation can be made in a bank to great advantage. The rafters must be strong and well supported. (Drawing from Extension Department, University of Saskatchewan)

poles are laid across the top. Then four or more alternate layers of straw and soil, from eight inches to a foot thick, are placed over the boards and extended to six feet or more beyond the sides of the pit. This cover should be well packed against the surface of the ground around the pit to prevent the frost from penetrating the space between the ground and the cover. Ventilators should be installed at intervals of about seven feet. A root cellar is constructed in much the same way, but is larger and provided with bins and a permanent door.

NOTE.—Send to the Department of Agriculture, Ottawa, for the bulletin, *A Practical Farm Root Cellar.*

The school garden. The school garden does not have to include many kinds of plants or be very large and it may take a variety of forms. For example the planning, planting, and care of a wind-break is a type of school garden activity that is well worth while. If a shelter belt has been started but allowed to become weedy and filled up with grass, splendid work can be

done in cleaning out these tree enemies and re-establishing good growing conditions for the trees. Even the planting and care of a window-box or two is a form of school garden.

A large vegetable or flower garden at school should be undertaken only when the supervision of an experienced gardener is available. It is essential also to arrange for the care of the garden during the summer vacation. If these two suggestions are neglected, school gardening activities may result in failure, and thus will have a very detrimental effect upon the students' interest in this branch of agriculture. If properly conducted, however, the school garden may be made to serve several very useful purposes. It may be a miniature experimental farm, where theories discussed in class are tried out. Small plots of various kinds of grains, grasses, or vegetable crops may be grown, and the students encouraged to prepare written reports at intervals during the growing season with the object of determining the comparative value of the varieties grown in their district. Various cultural practices may be tested. For example, three plots of carrots may be sown, one plot to be cultivated every week, another every two weeks, and the third every three weeks. A written record should be kept of the growth of the plants, the moist or dry condition of the soil, the growth of weeds, the final yield, etc. All other conditions, such as the quantity of seed used, the depth of seeding, thinning, etc., should be exactly the same for each plot.

Another very useful purpose of the school garden is to supply material for winter lessons in nature study, botany, entomology, and agriculture. Likewise if an account of all expenditures and receipts is kept, the students will receive good experience in farm bookkeeping.

The garden may be arranged in small plots or as one large garden in which all the students co-operate. The small plots are less desirable because they are not practical; they are neither like the garden which the student finds at home nor like that which he will have when he grows up.

Exercises and Problems

1. Arrange to visit one or two of the outstanding gardens of your locality. Ask the owner to show you the features of his garden. Visits such as these, will give you real pleasure, as well as valuable information.

2. Discuss with your class-mates the value of flower gardens from the standpoint of the community. Compare, for example, two streets, one with gardens surrounding the homes, the other without. Which one is the more pleasant place in which to live? Which one makes the more favourable impression upon visitors?

3. Is a hotbed worth while? Consider the labour and care involved, our short growing season, the economic advantages in respect to crops produced, etc. Suggest substitutes for a hotbed.

4. What conditions might cause a bin of vegetables to begin to spoil? How would you proceed to save the good vegetables in a bin in which spoiled ones had been detected?

Bush fruits. Fruits such as gooseberries, raspberries, blackberries, loganberries, strawberries, currants, and a few other native varieties are known as bush fruits. These are easily and profitably grown. In fact, it is quite possible for any gardener of average skill, on the farm or in town or city, to have in his garden a bush fruit section which, in addition to being a source of real satisfaction, will supply fruit in season for the table and for preserving.

The bush fruits are easily propagated by the following methods: gooseberries by layers, currants by stem cuttings and layers, raspberries by rooted suckers and by root division, blackberries by suckers and root cuttings, and strawberries usually by stolons or runners. These methods of reproduction are more fully discussed on pages 155-158. The student should read these pages.

The bush fruit section of the garden should be protected from the wind on the north, west, and south sides. A well drained location is essential. Strawberries and currants grow best on a northern slope, but a southern slope or level area will give good results if suitable methods are followed. The majority of the bush fruits grow best on a rich, moist, loamy soil. The soil should be thoroughly enriched by additions of well rotted barn-

yard manure and commercial fertilizers, both of which should be well worked in before the plants are set out. On the prairies in many cases summerfallowing for one or more years before setting out bush fruits is advisable.

New strawberry plants, as well as some of the other bush fruits, may be set out any time from the middle of May to as late as the first of September, but early spring planting is preferable. There are several methods of grouping the plants. Some gardeners arrange their plants in hills; others prefer a more compact plan. Depending upon the system followed, currants are planted from five to eight feet apart, gooseberries from four to five feet, raspberries from two to three feet in rows six or seven feet from one another, and strawberries are set out fifteen to eighteen inches apart in "matted" rows three and a half to four feet apart. Some growers plant strawberries in hills twelve to fourteen inches apart. In drier areas, the wider spacings are recommended. The tops of currant, gooseberry, and raspberry plants should be cut back after planting in order to balance the top with the reduced root system.

Thorough cultivation between the rows is necessary. It is a good practice to place a mulch or covering of straw between the rows early in the spring and leave it until the fruiting season is over. The mulch helps to conserve moisture and control weeds, and makes cultivation unnecessary except in the spring and fall months. In locations where there is danger of water erosion, some growers are growing cover crops between the rows. These crops are sown in the late summer and usually left until spring when they are ploughed under. Annual applications of manure and fertilizers are also desirable.

In more severe climates the less hardy varieties of raspberries require winter protection. The plants should be bent over and covered with soil until spring; or the tips of the canes (stems) only, may be covered with soil to hold the plants close to the ground so that they will be covered with snow during the winter. Strawberries should be covered, just after freeze-up, with about six

FIG. 89. Cuthbert red raspberry: left, before pruning; right, after pruning. (Photos from Horticultural Experimental Station, Vineland, Ont.)

inches of clean, coarse straw or hay, which is left in the spring until the season of alternate thawing and freezing is over, usually about the first week in May. When this covering is removed, enough is left to form a mulch to keep the berries off the ground.

The plants of the bush fruits require careful training to make them conform to the plan of planting that the gardener is practising. Pruning, too, is necessary in the case of gooseberries, raspberries, and currants to keep the stems upright, to remove old branches that have ceased bearing fruit, and to keep the centre of the bush open to admit light and air (Figures 89 and 90). Red raspberries produce fruit on one-year-old-canes, that is, on canes produced from suckers the previous year. After fruiting, the canes die; pruning, therefore, consists of removing dead canes and thinning new canes to the desired number. Pruning should be done immediately after the fruiting season. Currants should be trained to form a low, open bush. Black currants produce fruit on wood of the preceding year, and red currants on two- to three-year-old wood. From eight to twelve main shoots should be left, and it is important that these bear a large supply of wood of the proper age to produce fruit. Currant bushes should be pruned in the spring. The method followed in pruning gooseberries is similar to that outlined for currants. The fruit is

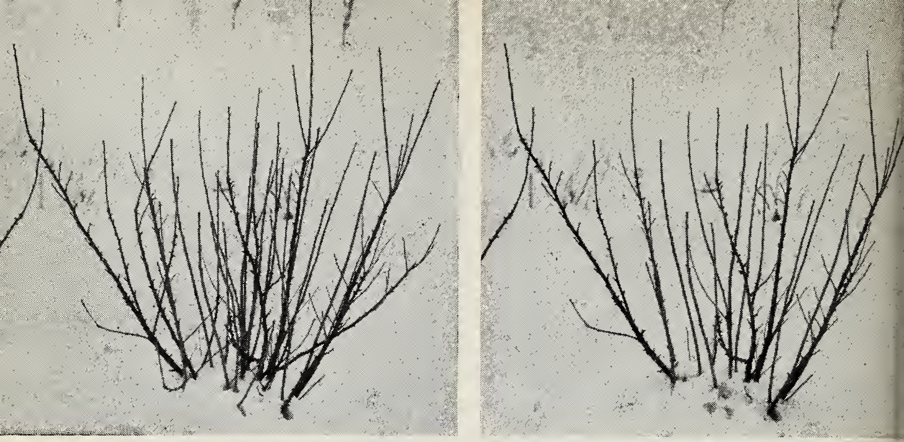


Fig. 90. A red currant bush: left, unpruned; right, after pruning. Five main fruiting branches have been left, also eight new shoots. In pruning red currants, the aim should be to remove wood that is becoming unfruitful (generally that which is over three years old), and to thin out the new shoots to six or eight evenly distributed shoots which will develop into fruiting wood. (Photos from Horticultural and Experimental Station, Vineland, Ont.)

borne on one-year-old wood and on spurs on two- and three-year-old wood. In currant and gooseberry bushes there should be no wood over three years old.

A constant watch should be kept for the appearance of disease or insect pests, and preparations made to spray the plants or treat them as otherwise required as soon as the presence of any of these plant enemies is detected.

Plantations of bush fruits should be replanted at intervals (strawberries, every three to four years, currants, gooseberries, and raspberries, about every ten years) as the plants lose their vigour.

Exercise

In a book such as this, only a few illustrative principles can be outlined in a discussion of fruit or other topics. Students, therefore, should prepare short accounts of the propagation, planting, care, pruning, and protection from disease and insects, of raspberries, gooseberries, currants, and strawberries, treating each one separately. The literature of the provincial and Dominion Departments of Agriculture should be consulted. (See page viii.)

The tree fruits. In many parts of Canada, it is comparatively easy to grow apples, pears, plums, and other tree fruits. In the

Prairie Provinces a number of varieties can be grown with considerable success. Though standard varieties of apples have not proved sufficiently hardy for most districts of the prairies, several varieties are being grown with some success; and a number of varieties of crab apples do well. While commercial varieties of plums are not generally satisfactory, native species have been improved to produce a well flavoured fruit of considerable value. Plum-cherry hybrids, produced by crossing commercial varieties of plums with the native sand cherry, have proved hardy, and bear fruit of good quality. Several strains of the sand cherry have also been improved, and can be grown successfully. When selecting varieties of fruit for the prairies, hardiness, productiveness, and quality should be carefully considered. In any locality the grower should select stock of proven merit and high quality.

FIG. 91. Plums in full bloom at Morden, Manitoba. (Photo from Dominion Department of Agriculture, Ottawa)

NOTE.—Space will not permit an extensive discussion of varieties of fruits. Teachers and students should consult authoritative publications of the Dominion and their own provincial Departments of Agriculture and Universities.

An orchard is definitely a long-term undertaking. For this reason a site should be chosen that will maintain production at a high level for many years. For commercial plantings, climatic conditions favourable to the fruits to be grown are necessary. Good air and water drainage are also essential. Land formations which permit the flow of cold air into "frost pockets" increase

the danger of frozen crops, and even partially water-logged soils are to be avoided as fruit trees require large amounts of air in the soil. Sandy to clay loams are suitable depending upon the kind of fruit to be grown. The soil should be deep (at least four to six feet), fertile, and free from alkali, and it should be well enriched also by a heavy application of well rotted manure. Summer-fallowing or the growing of a hoed crop for a year or more prior to the setting out of the trees is recommended.

Fruit trees are propagated by budding and grafting as illustrated and described in Figures 100, 101, and 102, and accompanying sections. In the Prairie Provinces, better results are secured by budding than by grafting. Hardy stocks should be used; for example, the hardy Siberian crab apple affords satisfactory stocks for the propagation of apple varieties. Young, well rooted trees should be obtained for setting out in the orchard.

Planting may take place in the fall or in the spring. On the prairie, early spring planting usually produces good results. The trees should be placed in the ground as soon as possible after they arrive from the nursery. If they cannot be planted soon after they are received, they should be heeled in. (See page 389.) When planting, some growers prefer to keep the roots moist by immersing them in a pail of muddy water. Trim off injured roots. Dig a hole large enough to allow the roots to be well spread out. In dry areas if possible, fill the hole with water, and allow the water to soak away. Work good top soil in around the roots, adding a little at a time, and tramp well unless the soil is wet. It is unsatisfactory to mix manure or fertilizer into the soil placed around the roots. When the roots are well covered, water again. Allow the top soil to remain in a loose condition. On the prairies, a slight depression should be left around the tree; in certain other localities the recommendation is to heap the soil up, two or three inches.

Fruit trees should be planted in rows in various arrangements. In localities, where water erosion is a possibility, contour planting is recommended. This means that the trees are set out in rows

FIG. 92. Evidence from Morden, Manitoba, that the right type of apple will produce abundantly on the prairies. (Photo from Dominion Department of Agriculture, Ottawa)

across the slopes rather than in straight rows which cross the slopes or contours without regard to direction. The following spacing is recommended: apple trees, fifteen to twenty feet for smaller varieties, forty feet for standard varieties; pears, twenty feet; plums, twelve to twenty feet; plum-cherry hybrids, ten to twelve feet; cherries, eight to thirty feet depending upon the variety. Many varieties of tree fruits are *self-unfruitful,* that is they will not produce good crops unless pollinated by some other related variety. Trees of at least two varieties of the same kind of fruit are necessary for fruitfulness, and three or four varieties are preferable. In larger orchards, where a main variety is desired, there should be at least one tree of the pollinating variety to every eight trees of the major stock. Wire guards should be provided to protect the trees from rabbits and mice. Certain repellents are also useful for this purpose.

General orchard management. Practices will vary greatly in different localities. Only a few general principles and suggestions can be outlined here.

Newly planted trees should be pruned as soon as possible after planting. During the first few years, it is essential to train the trees to the proper shape. The strongest type of tree has a main stem growing to the full height of the tree. However, a more open type with five or six main branches has advantages under certain conditions. If these main branches do not spring from a too centralized location, a tree of good strength will develop. In Western Canada particularly, the bush or open form of tree is recommended. It is recommended that, under prairie conditions, the newly planted tree should be cut back to within six inches of the ground. The cut end of the stub should be covered with grafting wax or other suitable preparation. From this stub, branches will develop to form a tree which will be resistant to strong winds and low temperatures. The second year, the branches arising from the stub should be thinned to five or six, well distributed around the stub. Each branch should be cut back to one-half its length. In other parts of Canada, while

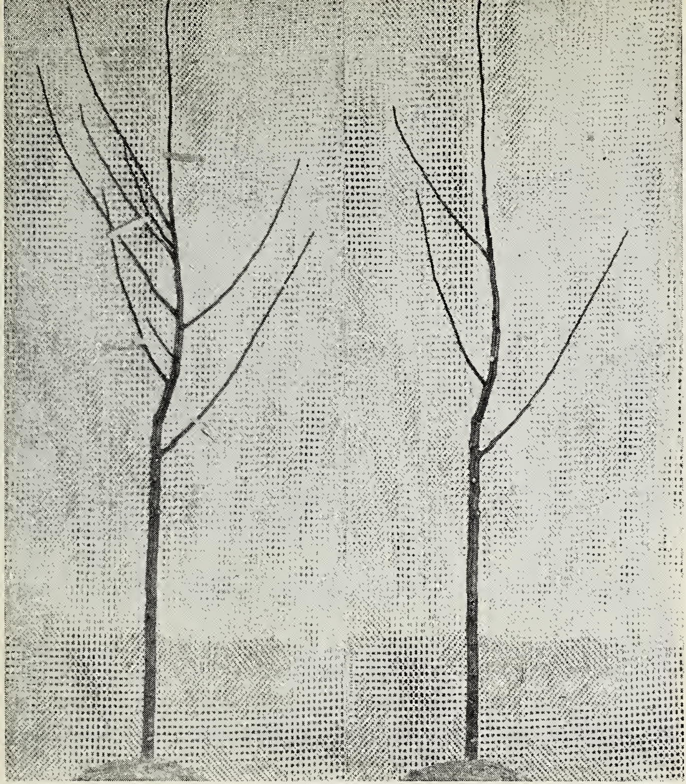


Fig. 93. A tree that has made good growth during its first year in the orchard; left, before pruning, and right, after pruning. It is being developed to have a strong central leader type of top. Under what conditions is this type of tree recommended? (Photo from Horticultural and Experimental Station, Vineland, Ont.)

some heading back is recommended, less drastic pruning is advisable. In Ontario, for example, the central leader system of tree development, with various modifications, is now favoured. During the subsequent two or three years of the tree's life, careful pruning is necessary to ensure well spaced, strong branches. A well balanced tree is desirable.

The application of commercial fertilizers to the orchard soil is frequently necessary, but the addition of fertilizer has not always produced desirable results. However, it is recommended that each grower study the fertilizer needs of his particular soil; then

Fig. 94. Tractor and disk harrow working in a cherry orchard. This tractor is designed and made with shields to protect the low hanging branches and permit working close to trees. (Photo from International Harvester Co.)

the amount and kind of fertilizer he applies should be governed by the type of soil and size and condition of the trees.

Early spring treatments of nitrogen are recommended in many areas. However, if nitrogen is applied too late in the season, the trees will continue to grow and will enter the winter with unripened wood which suffers damage from the frost. Fertilizers supplying phosphorus and nitrogen are sometimes necessary. Deficiencies of certain trace elements (see page 19) may need to be remedied; for example, in British Columbia boron has been applied with good results. Recommended fertilizers are: a general fertilizer containing nitrogen, phosphorus, and potassium; nitrate of soda, ammonium phosphate, ammonium sulphate, superphosphate, potash, and others. One authority advises that "fertilizers are not a cure-all and will not take the place of cover-crops and good cultural practices." However they do have some value in good orchard soil management.

Good cultivation is essential in the orchard. In general in the Prairie Provinces, grass and weeds should not be allowed to grow between the trees as they use moisture that is needed by the

Fig. 95. Apple orchard with a straw mulch around the trees. (Photo from Horticultural and Experimental Station, Vineland, Ont.)

orchard trees. A mulch of clean hay or coarse straw that is free from weed seeds may be placed over the soil under each tree. In other parts of the country the trend in the case of apples and pears, is away from clean cultivation to other systems such as a permanent sod mulch of grass or alfalfa. There is also a disposition to reduce cultivation in orchards of other tree fruits, although the stone fruits (peaches, plums, and cherries) do not respond as well to the system of sod culture. The objection to clean cultivation is that it tends to reduce the organic content of the soil and to increase the possibility of water erosion, an increasingly serious orchard problem. The grower should plan for as little cultivation as will serve his purpose.

The productiveness of an orchard is directly related to the maintenance of organic matter in the soil. Substantial amounts of humus should be added by means of cover crops, green manures, barnyard manure, sod, straw, and old hay. Where moisture is not the controlling factor, cover crops, such as rye, buckwheat, millet, clover, and others, may be sown after a period of cultivation to early July. During the winter, the cover crop has value

in holding the snow, which affords protection to the roots and prevents the alternate thawing and freezing of the ground. When the cover crop is disked or otherwise worked into the soil the following spring, large amounts of organic matter, and nitrogen, if the crop is a legume, will be added to the soil. Green manure crops, such as buckwheat, millet, soy-beans, or oats, have a large place in orchard management. (See page 29.) The addition of barnyard manure, with certain precautions, is also useful. The fruit grower, like other agriculturists, must study his soil and the particular requirements of the crop he is growing, and measure his results not by the immediate response alone but by the productiveness of the orchard year after year.

It is important to maintain the orchard in a clean, sanitary condition. Rubbish, shrubs, stone piles, or other things which may harbour injurious insects or disease, should not be allowed to remain among the trees. During cultivation, and pruning and picking operations, care should be taken to avoid causing injuries through which disease organisms may enter the trees.

Few, if any, operations necessary in the orchard are more important than spraying. The apparatus may vary from a hand pump to a good-sized power machine. In many cases, the spray should be applied with force. Constant mixing of the spray materials is also necessary. Upper and lower parts of the leaves, and at times all parts of the buds and fruit, should be well covered. The following discussion of spray mixtures is for reference only. It will serve only to indicate the variety of materials available and the skill required to select the right one.

Bordeaux mixture (see page 202) is a fungicide commonly used to control such plant diseases as apple scab, leaf spots of pears, apricots, strawberries, currants, and gooseberries; leaf curl of peaches and apricots; anthracnose and spur blight of raspberries and blackberries; brown rot of plums and cherries; and blackknot of plums. When 2½ pounds of calcium arsenate are added to 100 gallons of Bordeaux mixture, the spray is effective for insects such as the tent caterpillar and cankerworms. Lead arsenate,

FIG. 96. Spraying at the right time with the correct insecticide or fungicide is an essential practice in profitable orchard management. (Photo from Canadian Industries, Ltd.)

3 to 4 pounds in 100 gallons of Bordeaux will control the codling moth, apple maggot, plum curculio, raspberry fruit worm, currant sawfly, strawberry leaf beetle and leaf roller, and aphids. Lead arsenate, 3¾ pounds with hydrated lime, 7½ pounds in 100 gallons of water will destroy borers, sawflies, etc.

Lime sulphur, 2 gallons in 100 gallons of water, is an effective fungicide for apple scab, anthracnose and spur blight of raspberries, strawberry leaf spot, currant and gooseberry mildew, leaf curl of peaches, etc. Mixed with hydrated lime and lead or calcium arsenate, the spray may be used to control insects such as casebearers, tent caterpillars, cankerworms, etc. Another fungicide, microfine sulphur, which is available under several trade names, in the proportions of 8 pounds of sulphur, 3¾ pounds of lead arsenate, and 100 gallons of water produces a spray which can be used to control many of the diseases and insect pests that have been mentioned. Certain diseases, and bud moths, aphids,

leaf hoppers, and other insects may be held in check by nicotine sulphate in various proportions in water, Bordeaux mixture, or lime sulphur. Laundry soap is useful in some sprays; for example, a spray of soap, sulphur, and water may be used for aphids, red spiders, and disease. Dusts of nicotine, Bordeaux, sulphur, arsenate of lead, calcium, or dehydrated lime are effective for biting insects and fungous diseases, but must be applied when the air is calm and the foliage damp. Dormant oil emulsion in various formulae, one of which is 3 gallons of dormant oil, 6 ounces of bluestone, 6 ounces of hydrated lime, and 5 gallons of water as a stock solution to be diluted with 100 gallons of water or Bordeaux mixture, will control such insects as leaf rollers, red mites, scale insects, and aphids. DDT, using 2 pounds of 50 per cent DDT wettable spray powder in 100 gallons of water, will destroy insects such as the codling moth, apple maggot, oriental fruit moth, etc.

The provincial Departments of Agriculture publish spray calendars as an aid to farmers; these suggest the most effective sprays and the best times of application for various fruits.

References

Fruit Growing in Saskatchewan; Extension Department, University of Saskatchewan, Saskatoon.

Establishing the Young Orchard, Orchard Soil Management, Pruning the Tree Fruits, Small Fruits for the Home Garden, and others; Department of Agriculture, Toronto.

Selection of Orchard Sites and Soils, Orchard Cover Crops, Diseases of Fruit Trees; Department of Agriculture, Victoria.

Problems

1. Investigate the problems of fruit growers in your locality. What plant diseases, insect pests, and soil difficulties are troublesome? What practices are being followed to ensure good crops?

2. What are the prospects of successful fruit-growing in the Prairie Provinces? What special difficulties are encountered?

3. What pruning operations will encourage an unproductive currant bush to produce fruit? an apple tree?

4. Orchard soils should be deep, mellow, fertile, well drained, and free from alkali. Discuss each characteristic, explaining its meaning and significance.

CHAPTER 7

THE PROPAGATION AND IMPROVEMENT OF PLANTS

Plants have developed many different methods of propagating or reproducing themselves naturally. In addition to these man has devised other methods, more or less artificial but remarkably skilful, of reproducing and improving plants.

Natural propagation. Seeds are perhaps the most common means of plant reproduction. Many devices are employed by plants to disperse their seeds when ripe and to prevent overcrowding. What are some methods of seed dispersal?

Another common method of plant reproduction is by means of underground stems or rootstocks which are found on such plants as the thistles and many of the grasses. The rootstock creeps along just below the surface of the ground and sends up new plants at the joints or nodes; tubers of potatoes are swollen underground stems.

Stolons or runners are produced by such plants as the strawberry. The stolon is sent out by the parent plant along the surface of the ground, and takes root at the nodes, producing new plants. These, when well established, may be transplanted.

Suckers are shoots that spring underground from the parent plant and take root, sending up a new plant, which becomes independent when the sucker is severed. Roses, red raspberries, and blackberries reproduce in this manner.

Lilies, onions, and other plants of the same family are reproduced by bulbs, which are modified forms of buds. The onion is a good example of this type of plant. It is composed of buds, which are surrounded and protected by layers of thick, fleshy leaves, growing from a very short stem above a dense fibrous root.

Flowerless plants, such as fungi (rust, smuts, mushrooms, toadstools, etc.) and ferns, are reproduced by spores. If the *frond* (leaf) of a fern is examined, many tiny brown dots will be

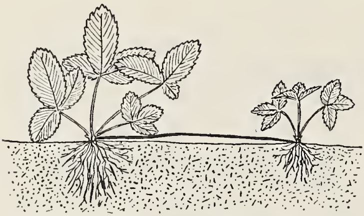


FIG. 97. A runner or natural layer of the strawberry.

found. These dots are groups of spore cases or *sporangia*, which are filled with numerous microscopic bodies called *spores*. When the spores are ripe, they fall to the ground and, after undergoing a special development, produce new ferns. Spores and seeds should not be confused; they serve a similar purpose, but are different in other ways. For example, a spore may live for years in adverse conditions.

Exercise

Obtain a fern frond bearing sporangia. Examine it under a good magnifying glass or low-power microscope. Scrape some sporangia off, and prepare a slide. (See page 64.) Crush some of the spore cases before placing the cover-glass over them. Gently press on the cover-glass with the point of a knife, and observe the spore cases open. Draw what you see.

Methods of plant reproduction devised by man. Some of the methods of reproduction discussed in the foregoing paragraphs may be either natural or artificial, but the following very rarely occur naturally, having been developed by man to increase plant propagation.

Cuttings are parts of the roots, stems, or leaves of growing plants, from which new plants of the same kind may be developed. For example, blackberries may be propagated by root cuttings, which are made either in the fall or in the spring.

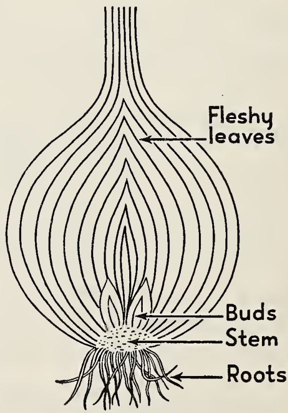


FIG. 98. A lengthwise section of an onion—a typical bulb.

If the cuttings are made in the fall, they are stored in sand over winter. The root is cut into pieces two or three inches long; when these are planted in moist soil, new plants are produced. Rhubarb roots may be dug up in the spring, divided into sections, and replanted to produce new plants.

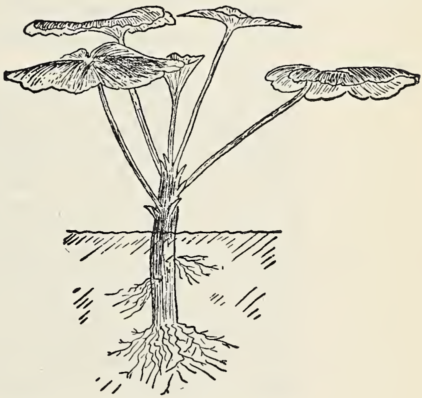


Fig. 99. A rooted soft wood stem cutting.

Plants like the geranium, coleus, patience, etc., are propagated by slips or soft wood stem cuttings, made from the younger parts of the plant. The section of the stem to go underground should have several nodes, since the new roots develop from these points. Slips may be started in water, moist sand, or clean damp soil and should be shaded from the direct rays of the sun for a few days. Plants with woody stems, such as currants, grapes, willows, and poplars, may be multiplied by hardwood stem cuttings. These cuttings are prepared both in the fall and in the spring. Well matured young branches bearing buds are cut into pieces eight or ten inches long. Frequently they are planted at once, or, when made in the fall, they are stored until spring in sand or light soil. These cuttings should be placed in the ground obliquely and quite deep, leaving only one or two buds above the soil. A good supply of moisture is essential.

Good results are being secured by treating cuttings with certain synthetic substances having the properties of *hormones*. Hormones are those mysterious secretions, one of the functions of which is to stimulate reproduction in both plants and animals. Their presence quickens the rate of cell division and expansion and consequently speeds up plant growth. Cuttings may be treated by standing them for a certain time in a solution of the

chemical or dipping the basal ends into a dust containing it in powdered form. Not only is the rapidity of rooting increased, but cuttings may be made at various times of the year.

Hormones also have value in stimulating germination and the development of young plants as well as the healing of wounds in grafting and cutting. Their use on a practical basis has not, however, been fully established.

Projects

1. Potting a plant. Thoroughly wash and drain the pot. Place a few pieces of broken crockery or small stones in the bottom for drainage. Next put in enough soil to touch the roots when the plant is held in place. Then hold the plant in the middle of the pot, and carefully pour in soil around the roots, packing it around the sides as it is being poured in. Keep the roots well spread out. The pot should be filled with soil to within half an inch of the top. Finally, water the soil freely but gently. What kind of soil would you recommend for potting plants? Give reasons for your recommendation.
2. Start a geranium cutting in moist sand or soil. After two or three weeks, dig it up, and examine the parts that have been underground to determine the points at which roots developed.

Layers are really cuttings, but the branch used is allowed to remain attached to the parent plant until it has taken root. Gooseberries are propagated in this manner. In early spring the plants are cut to a height of six inches to encourage the production of young shoots. When these are a few inches high, the earth is heaped up around and through the bush until only the tips of the young shoots remain uncovered. The soil should be packed to retain moisture. By fall, the shoots will have developed roots, and may be separated as independent plants for transplanting. Grapes may be propagated by covering a vine with soil at intervals. Roots develop at the buried points, forming new plants. This method may be used also with gooseberries.

Grafting is the practice of making a branch from one tree grow on another. There are two parts to every graft,—the *scion*, (sī′on) the branch grafted on, and the *stock*, the stem to which the scion is grafted. The stocks may be grown from seed.

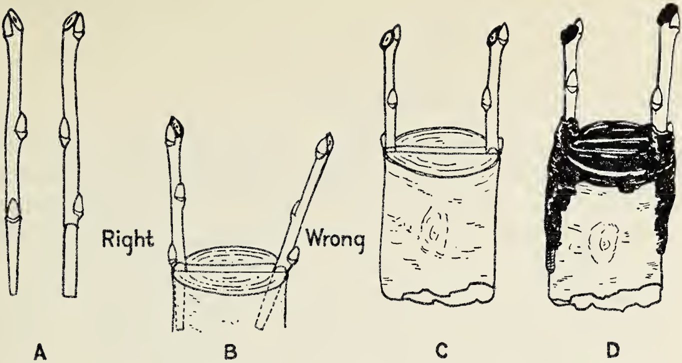


FIG. 100. The steps in cleft grafting. The limb is split by pounding grafting tool or knife with a wooden mallet or piece of wood; and the cleft is opened to insert the scions. A—two views of the scions; B—right (on left) and wrong (on right) placement of scions; C—scions in place; D—after covering the wounds with grafting compound. (Drawings from the Horticultural Experimental Station, Vineland, Ont.)

The scion retains the characteristics of the tree from which it was taken. It will grow and use the solutions sent up by the roots of the stock but will always produce leaves, flowers, and fruit similar to its parent tree. A scion from one tree may be made to grow upon another tree only if the two plants are closely related. For example, the branch of one kind of apple may be successfully grafted to another kind of apple tree but not to a peach or other species of tree.

Grafting is practised for special purposes with fruit trees, such as apples, pears, oranges, lemons, peaches, and plums. Some varieties of these fruits do not reproduce their good qualities when grown from seed. A number of rootstocks are, therefore, started from seed, and, when they have become well established, branches from a tree with desirable characteristics are grafted on them. Thus, the fruiting area or the framework of an established tree can be changed from one variety to another. Likewise, the tops of a few trees in an orchard may be changed to a variety that will be an effective pollinator for the main variety. In young trees the production of fruit may be advanced several years by grafting on them branches from mature trees. If mice or rabbits have girdled a tree, or if it has been otherwise damaged, its life frequently may be saved by bridging across the wounded part with five or six scions.

There are a number of methods of grafting. The cleft graft is practised where two or more scions are grafted on one stock, which is larger than the scions. Four or five well spaced limbs are selected, with a view to having the new top as symmetrical as possible, and cut off straight across. Each stock is then split lengthwise for a short distance. The scions, which must be in a dormant state, are cut in the shape of a blunt-pointed wedge and fitted securely into the cleft or split in the stock. Great care should be taken to make certain that the cambium layers of the two parts of the graft are placed and held in close contact. They will not grow together otherwise. Why? As soon as the scions are in place, all exposed surfaces should be covered with grafting wax to prevent the escape of sap and the entrance of disease germs. Grafting wax is a preparation consisting of five pounds of resin, one pound of beeswax, four fluid ounces of raw linseed oil, and four ounces of lampblack or powdered charcoal. Special asphalt emulsion grafting compounds are also available. A year after the grafting operation, the balance of the original top should be removed. The tree has thus been given a new top.

The whip and tongue graft is used when the scion and the stock are the same size. The top of the stock is removed with a long, slanting cut, and the lower part is then split back, making a tongue. The scion is cut in the same manner. The two parts are then fitted tightly together and bound with waxed strips of cloth, cord, or paper.

Frameworking consists of grafting 50 to 250 scions to the original main and secondary branches of a tree; that is, the main branches are not removed as in cleft grafting. Two types of grafts are recommended, the stub and the oblique side as illustrated. Wounds are smaller in these cases than wounds caused by the removal of larger limbs in top grafting and heal more quickly. Consequently, the tree returns to production much sooner.

Grafting is usually done in the spring or early summer. The best scions are mature branches of the previous season's growth and should bear several well developed buds. They may be cut

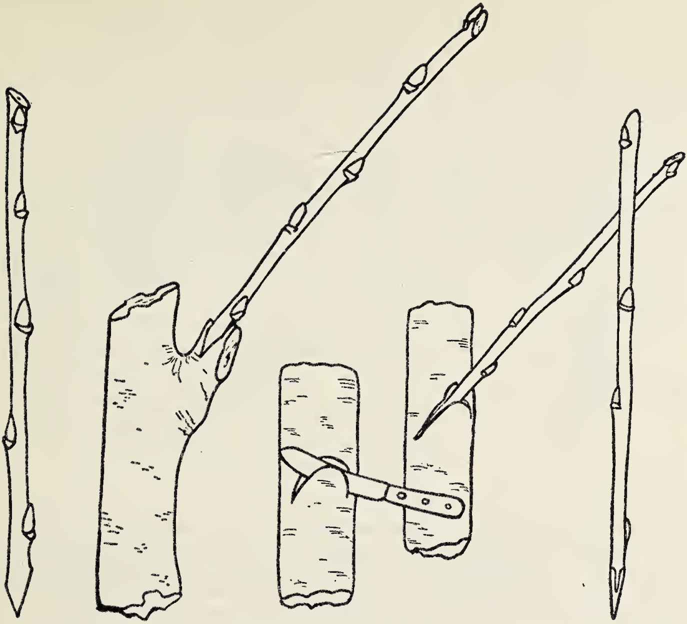


Fig. 101. Left: scion prepared for stub grafting. In the second diagram the scion is in place and the branch is cut off close to the base of the scion. Right: oblique side grafting—making the cut, the scion in place, and a prepared scion. All wounds are finally covered with suitable grafting wax. (Drawing from Horticultural Experimental Station, Vineland, Ont.)

in the fall after the leaves have fallen, or in the spring just before the grafting takes place. When cut in the fall, the scions are packed in sand, sawdust, peat, or moss during the winter, and kept cool and moist until they are required.

Budding is a modification of grafting, and is used with the stone fruits such as peaches, cherries, plums, and apricots, and with trees that are too small for grafting. A single bud is removed from the branch of one tree and made to grow beneath the bark of another. Buds are secured from terminal shoots of the current growing season. (See illustration for part used.) Shoots thus prepared are known as *bud sticks.* In cutting out the bud, care must be taken to remove the bud and the cambium layer behind it without any wood. The leaf stalk, which springs from just below the bud, is usually left in place to serve as a handle and to

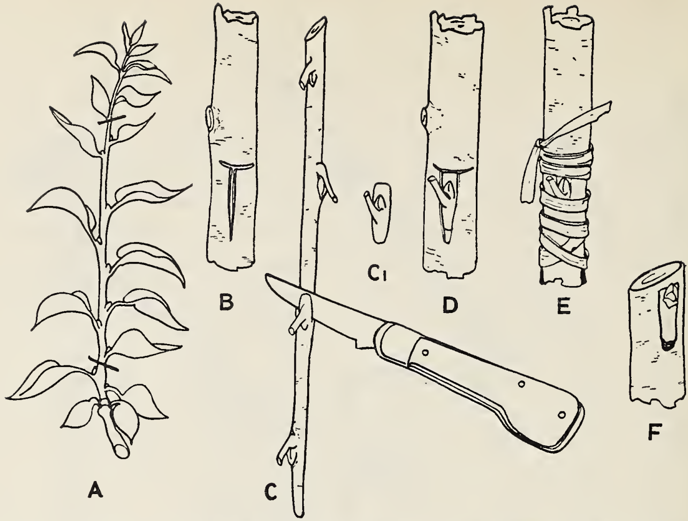


FIG. 102. Shield budding. A—terminal growth of current season, the source of buds; B—the T-cut in the stock; C—the prepared budstick showing the cutting of the bud; C_1—the shield bud; D, E—the bud in place and tied tightly against the stock with raffia; F—the branch of the stock cut off close to the bud in the following spring. (Drawings from Horticultural Experimental Station, Vineland, Ont.)

indicate whether the bud lives. A T-shaped cut is made in the bark of the stock; the flaps of bark are loosened and bent slightly back; the bud is then inserted and tied into place with *raffia* (a fibre tying material). It is essential to get the cambiums of the two parts together. Budding must be done in the summer when the cambiums of both scion and stock are in active growing condition.

Exercises

1. Why is grafting not useful as a method of producing new varieties? How are new varieties of fruits produced?
2. Using branches of any trees available—poplar or other soft wood—prepare exhibits of several methods of grafting.

NOTE.—Two good references are: *The Budding and Grafting of Fruit Trees* (Illustrated Folder), Dominion Department of Agriculture, Ottawa; and *Orchard Grafting*, Ontario Department of Agriculture, Toronto.

The improvement of plants. Most of our cultivated crops have been developed from plants that originally grew wild in

some part of the world; in fact, wild wheat is still to be found in Palestine. During the thousands of years that these plants have been used by man, they have been very greatly improved; but, unless constant effort is made to retain this improvement, they tend to revert to the original wild forms and thus lose the good qualities which man has developed in them. In spite of all that has already been accomplished, much has still to be done to make our crops easier to grow and more profitable to the farmer.

Variations and mutations. Variations and mutations are the basis of all improvement in either plants or animals.

No two living things are exactly alike in every respect. Compare your hands with those of a class-mate, or compare two leaves, flowers, etc., of the same species. A *variation* is the difference between plants or animals of the same kind; for example, the difference between two elm leaves. The difference between an elm and a maple leaf, however, is not a variation.

Variations may arise from two causes. In the first place, the soil, climate, and other factors in the environment of plants produce differences in them. Plants that are not fitted to survive in their surroundings attempt to develop variations in structure and methods of living, and thus adapt themselves to the conditions around them. It is surprising how quickly plants change their habits of growth to meet new conditions. State several examples. Variations due to environment are not considered to be permanent, that is, they are not transmitted to offspring. On the other hand, cross-pollination brings about the union of the characteristics of two plants into one plant and results in variations which are permanent and inherited.

By taking advantage of superior variations, man is able to develop plants and animals more suitable for his purposes than those which existed previously.

Mutations are sudden distinct changes or variations which appear unexpectedly in a plant or an animal. The plant or animal upon which the mutation occurs is called a *mutant*. For example, a very leafy plant might grow from seed produced by a

Fig. 103. Crossing wheat. Each head is wrapped after it is pollinated to protect it from pollen from other wheat flowers. The covering is removed after fertilization. (Photo from Department of Field Husbandry, University of Saskatchewan)

plant which is not leafy and the ancestors of which were not leafy. The plant would be a mutant, and the leafy characteristic a mutation. Mutations are important factors in the improvement of our crops and live stock, because they are transmitted by the mutant to its offspring and inherited by succeeding generations.

Heredity. If the characters of a plant are fixed or permanent, they will be inherited by the offspring of the plant and again transmitted by the offspring to their descendants. Temporary characters are not inherited.

Crossing. Crossing is brought about by cross-pollination between two plants more or less closely related. The offspring are called *crosses* or *hybrids*. The objects of crossing are to combine the characteristics of two or more plants in one (the offspring) and, if possible, retain the good qualities and eliminate the undesirable characters of the parents. When two plants are crossed, their characteristics, both good and poor, are transmitted to the offspring, and it requires a great deal of work and skill on the part of the plant breeder to detect plants among the offspring that possess the good qualities of the parents.

The first step in crossing is to select carefully the two parent plants to be used. The stamens from some of the flowers of one plant are then carefully removed to prevent self-pollination. This step is called *emasculation*, and must be done before the stamens have produced pollen. By means of a small brush, pollen from the flowers of the second plant is then dusted over the stigma of the flowers of the first plant. To prevent the

flowers which have been crossed from receiving pollen from any other source, they are covered by a paper bag until seed has been formed.

How Marquis wheat was produced. Marquis is an example of a cross-bred wheat of outstanding worth. In the pioneer days of the western prairies, Red Fife was the variety of wheat most commonly grown. Red Fife was an excellent bread-making wheat, but ripened so late that early fall frosts often seriously damaged the crop. An earlier maturing wheat was needed. William Saunders, the first director of the Dominion Government Experimental Farms, initiated the effort that resulted in the production of Marquis wheat. Under his direction, crosses were made between Red Fife and Hard Red Calcutta wheat, an early maturing but inferior variety. From the crosses produced, Dr. (later Sir) Charles E. Saunders, a son of William Saunders, discovered and selected desirable plants. He planted the seed from these, and again made selections from among their offspring.

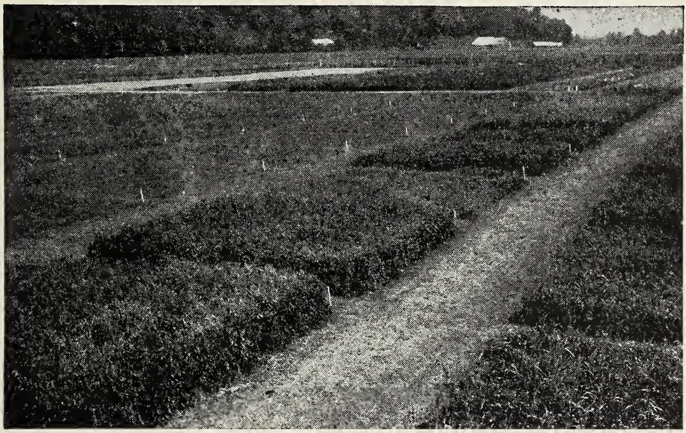


Fig. 104. Hay and pasture plots at the Experimental Farm, Agassiz, British Columbia. By conducting extensive experiments, the agriculturist discovers which crops are best for different farm conditions. (Photo from Dominion Experimental Farm, Agassiz, B.C.)

After many years of painstaking work, he finally produced a new variety, which he called Marquis. This wheat possesses the bread-making qualities of the Red Fife, ripens about a week earlier, and does not shatter as readily.

The great work of producing new and better varieties of crops is still going on. Other cross-bred wheats of high value are discussed on page 84. Watch the newspapers and other publications for accounts of new varieties of crops.

Selection. New varieties have been created, and a great deal has been accomplished in the improvement of existing varieties of crops by the careful selection of good seeds and plants. *Selection* means the choice of the best for use in producing more good plants, the poor being discarded. Better crops are produced from the seed of plants selected for such qualities as high yield, resistance to disease and drought, early maturity, etc. Nature also practises a rigid scheme of natural selection. Plants that are not fitted to live in their surroundings die, for nature chooses only the strong and the fit to live and become the ancestors of succeeding generations. Is there any relation between this statement and the discussion of variations produced by environment (page 163)?

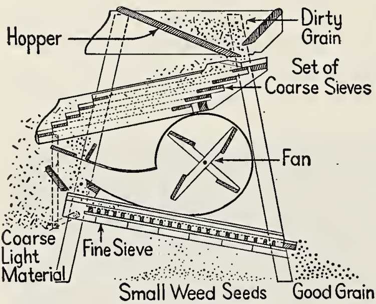


Fig. 105. Diagram illustrating the operation of a fanning mill. Study the diagram carefully, and explain how weed seeds, cracked small light shrunken wheat, bunt balls, and other grains are removed from a sample of wheat. It is frequently necessary to run the grain through twice.

Seed selection. There are two methods of selecting seed. It may be done mechanically by the use of a fanning mill or by hand.

Exercise

Obtain about two quarts of wheat of medium quality. Carefully work over it, selecting and separating the large, plump, bright-coloured

kernels from the balance of the grain. When you have two piles, weigh an equal volume from each. Account for any difference in weight. Thoroughly mix each pile, remove a representative sample, and make a germination test. Estimate how much you have improved the germinating power of the wheat by removing the poor seeds, etc. from it. Would the yield and the quality of the crop thus be improved? Give reasons.

In selecting seed, it is important to know what qualities are most desirable and will produce the best results. The following are characteristics of good seed: (1) Large and uniform in size, well filled out, good weight. (2) Bright and deep in colour, not bleached. (3) Clean, *i. e.* free from weed seeds, straw, and other foreign material. (4) Free from smut, rust, or damage by frost or insects. Seed grain should be tested for smut, and replaced by disease-free seed or treated if a trace of smut is found. (5) Pure, *i.e.* not mixed with other varieties or other kinds of seeds. (6) Well ripened. (7) Of strong germinating power. If there is any doubt about the vitality of the seed, it should be tested; by so doing, much useful information may be obtained about the strength and the life of the seed in question.

In some places, Ontario for example, seed cleaning plants equipped with seed cleaning and in some cases, seed treating machinery, have become fairly general.

Germination test. The following test is one way of finding the percentage of seeds that will germinate in a given measure.

Exercise

Obtain samples of grain, grass, and vegetable seeds. In each case thoroughly mix the samples to be tested. Why? Count out 100 seeds. Place them between sheets of moist blotting paper on trays or plates. Keep the blotting paper damp. Place the seeds where the temperature will be about 68°F. After three or four days, count and remove seeds that have germinated both root and stem. Keep an accurate record of all seeds counted. Continue to count and remove sprouted seeds every second day for about two weeks. Since 100 seeds were used, the total number of sprouted seeds will be the percentage of the entire sample that will germinate. If blotting paper is not available, cloth may be used, or the test may

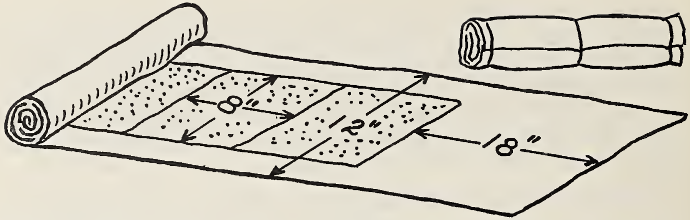


Fig. 106. The rag-doll seed germinator and tester. To make a rag-doll germinator: Cut a strip of fairly heavy flannel or cotton ten or twelve inches wide and two yards long. With a soft lead pencil, mark off squares as indicated in the diagram. Dampen the cloth. Place fifty large or a hundred small seeds in each square. Seeds must not touch one another. Roll up the cloth, and loosely tie each end and the middle of the roll with elastics or strings. Soak the roll in a pail of luke-warm water for several hours. Drain off the water, and cover the pail with a damp cloth and newspapers. Keep the roll damp, but not wet, and in a warm place. After five or six days, the roll may be opened and a count made to determine the percentage of seeds that have germinated.

be performed by planting the seeds in shallow boxes of soil, sand, or sawdust. Figure 106 suggests a good method of making a test.

Project

Arrange with farmers to send in seed to be tested. Point out that the samples should be representative. Carefully test the seed received, and report results to the farmer.

The advantages of good seed. Long, careful experimenting has proved that the best seed will, year after year, produce the best crops. Every farmer should save his choicest seed for planting. Good seed helps the crop to an earlier start, so that it is not crowded out by early weeds and is ripe in the fall before the seasons of rust and frost. When the seed is clean, it runs through the drill better, and there are fewer weeds or other grains to waste food and moisture and produce a dirty crop subject to heavy dockage. Good seed will germinate more evenly, and, other conditions being equal, the crop will be more uniform and higher in quality.

Individual plant selection. In this method of improving crops, a single plant displaying the desired qualities is selected. Seed from this plant is sown the following year; and from the crop

FIG. 107. Test plots of oat varieties on the College of Agriculture farm, Saskatoon. Each plot is a miniature field. Notes on earliness, height, straw strength, etc., are taken on the central eight feet of the three centre rows of each plot. (Photo from Department of Field Husbandry, University of Saskatchewan)

produced, selections are again made. Finally, when it is evident that the good characters of the parent plant are fixed and will be transmitted from one generation to the next, the supply of seed is multiplied to produce sufficient for general sowing.

Mass selection of wheat heads. The procedure followed in mass selection is to select by hand from the general crop, heads of wheat which are true to type and variety, free from disease, filled at the top and bottom, and otherwise superior. Usually from twenty to forty pounds of heads are picked. This amount, when threshed, will sow about a quarter-acre. The seed is sown the following spring on clean land, free from volunteer grains. During the summer, the plot must be *rogued* at intervals. To do this, the grower walks through the plot and pulls up all plants that appear to be diseased, off type, or of other varieties or kinds of grain. The seed from the smaller plot is used to sow a larger area. In this way the seed is gradually multiplied for general use. By continuous hand selection it is possible to keep the crop pure as to variety and, to some extent, improve its quality and yield. Every precaution should be observed at all times to

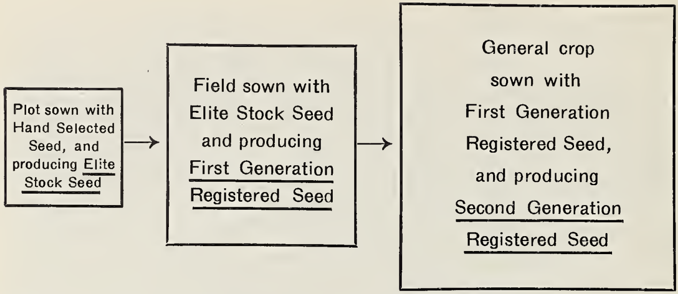


FIG. 108. Diagram illustrating the method followed by members of the Canadian Seed Growers' Association in producing registered seed.

prevent the seed from being mixed with other grain. Hand selection may be used to improve other crops by carefully selecting pods, panicles, ears, tubers, etc., from sound, vigorous, normally developed plants in the general crop.

Registered pedigreed seed. Registered seed is seed of known origin or ancestry. The buyer knows where and by whom it was produced. Registered seed is highly desirable because: (1) It must be 99.99 per cent pure. (2) Only desirable varieties are registered. (3) It is inspected before harvest, and only high quality, disease-free seed is allowed to be registered. (4) It is clean. (5) Each sack is inspected and sealed by a government inspector. (6) Registered wheat must germinate 95 per cent, and oats and barley 90 per cent. The regulations governing registered seed are formulated by the Canadian Seed Growers' Association, Ottawa, which organization also records the pedigrees and issues certificates of registration.

The production of registered seed begins with a plot of *elite stock seed,* which is the name given to the seed taken from a hand-selected seed plot or from a seed plot that was sown with seed originating from a single plant. Elite stock seed produces first generation registered seed, which in turn produces second generation seed. If a crop or the seed from a crop does not meet the requirements necessary to be registered it may be classed as

certified. The standard required for certification is not as high as for registration; for example, certified seed must be 99.9 per cent pure as compared with 99.99 per cent specified for registered seed.

Registered seed is sufficiently plentiful and low priced to enable a farmer to buy a small quantity, sow it on a good piece of clean land and produce his own high quality seed. It has been demonstrated that registered seed returns greater profits than other seed but care should be taken to select only a recommended variety.

Project

Write to the Canadian Seed Growers' Association, Ottawa, for information about the growing of registered seed. Boys and girls can make a success of growing registered seed; this might become an interesting and profitable project.

Certified seed potatoes. The three classes of seed potatoes, Certified, Certified Foundation A, and Certified Foundation, must be produced, stored, and sold according to established standards and regulations.

If certified seed potatoes are to be produced, fields must be rogued and inspected. Only seed potatoes from fields planted in tuber units can be classed as Foundation A or Foundation potatoes. A tuber unit is a series of two or more consecutive plants grown from sets cut from one tuber. Certified potatoes must be 97 per cent free from disease and 99.9 per cent free from foreign varieties; Foundation A standards are 99.5 and 99.9 per cent; and Foundation seed potatoes should be 99.9 per cent free from disease and 100 per cent free from other varieties.

The production of new varieties by selection. Dr. Seager Wheeler, while working among the seed plots on his farm at Rosthern, Saskatchewan, discovered Red Bobs, which is a selection from an Australian wheat called Bobs. Kitchener is another variety of wheat originated by Dr. Wheeler. It was developed from a single plant selected in a field of Marquis.

Strains within varieties. A system of careful selection may also be employed to develop strains within given varieties. The strain produced is usually an improvement on the original variety.

Selection on the farm. A good farmer practises selection although he may not be able to follow the methods just described. But he should clean his seed thoroughly by means of a fanning mill (mechanical selection). He should also search for clean areas of particularly good quality in his growing crops, and harvest and thresh such parts of his crop separately for seed purposes.

The importation of new varieties. The crops which are being grown in a country may sometimes be improved by importing better varieties from some other part of the world. The new plants may be used for general production or for crossing purposes. Crested wheat grass (see page 101) is a good example of a valuable imported crop and Marquis wheat, a Canadian product, was introduced into and widely grown in the United States.

Cultural methods of improving plants. By carefully preparing a good seed-bed, sowing the best seed at the proper depth and during the right season, and in every other way giving the crop the best chance to develop, better crops can be produced. Improvement secured in this way is not permanent and is lost as soon as good methods are abandoned, but it is important nevertheless.

The possibilities of plant improvement. The work involved in the improvement of plants is often slow and tedious, but there are great possibilities in it. Luther Burbank, Sir Charles Saunders, and many others have succeeded in producing new varieties of great value. There will always be a need for new and improved varieties of crops. While wheat is the chief crop discussed in the preceding paragraphs, the principles dealt with apply equally well to the improvement of all crops of the field, garden, or orchard.

Project

Study the work of prominent plant-breeders. Clip from newspapers and magazines accounts of men in Canada who are doing

outstanding work in the improvement of our crops. Make a collection of this information.

Experimental farms. Experimental farms have been established in all parts of Canada. The provincial Experimental Farms are situated at the provincial agricultural colleges. The Dominion Experimental Farms Service comprises the Central Experimental Farm, Ottawa, twenty-six Branch Farms and Stations, fourteen Sub-Stations, 211 Illustration Stations, and nine Branch Laboratories.

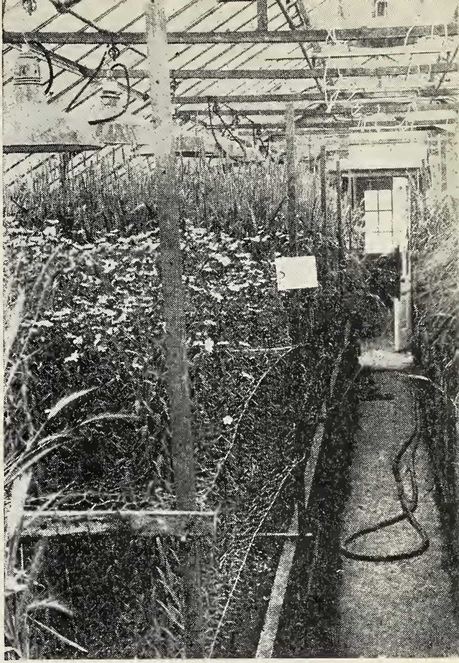


FIG. 109. Flax hybrids (in blossom at the left) being grown to maturity in the greenhouse during the winter to accelerate the program of flax improvement. Note the chicken wire used to separate plants. (Photo from Department of Field Husbandry, University of Saskatchewan)

The various Experimental Farms and Stations carry on research, experimental and demonstrational work in animal and poultry husbandry, agriculture, plant breeding of cereal, forage, horticultural, fibre, and tobacco crops, field husbandry and agricultural engineering, and other phases of agricultural activity. The work of the Experimental Farms, ranging from simple tests to complicated investigations involving laboratory research, has the ultimate objective of direct application of results to farming. By this means much valuable information is collected and distributed free to farmers in all parts of the Dominion. Try to arrange a visit to an Experimental Farm.

NOTE.—A good account of the types of work carried on by the Dominion Experimental Farms is found in the booklet *Dominion Experimental Farms*, available on request from the Department of Agriculture, Ottawa. (One copy per school.)

Exercises

1. While it is true that a farmer can do little to improve his crops by crossing, it is also true that he can do much in other ways. What means of improving his crops are available to the average farmer?
2. What are the advantages of growing registered grain?
3. How does a plant-breeding expert proceed when he attempts to produce a new variety of crop? Which process, crossing or selection, do you consider the more important? Give a reason for your answer.
4. Why should farmers be careful about accepting new varieties before their value has been well established? Discuss the possibility of disastrous results when untried new varieties are sown.
5. What is the value of a membership in an organization such as the Canadian Seed Growers' Association? In what way is an organization of this type of value to the average farmer?
6. How do the Experimental Farms Branch, Ottawa, and the provincial agricultural colleges make the results of their plant-improvement work available to the farmer? (See pages viii and 37.) When a small quantity of seed of a proven new variety is produced, what must be done to make seed available for general distribution?
7. In what respects do existing varieties of wheat appear to require improvement? What information have you of recently released new varieties?
8. The name and the work of Sir Charles Saunders are well known. But more recently, other Canadian scientists have produced new varieties of proven merit. Try to learn the names of these men, where their work is being done, and the details of their contribution to agriculture in Canada.

Scientific method. As you read this book, you will learn of the great advancement that has been made in farming as a result of the work of agricultural scientists. In several places (pages 1 and 24) you have been urged to use the methods of the scientist in your thinking and activities. If you understand and practise the scientific method, your ideas will be clearer and your undertakings more accurate and therefore more successful.

CHAPTER 8

WEEDS—THEIR INDENTIFICATION AND CONTROL

A weed has been defined as a plant growing in the wrong place. A noxious weed is one that is especially injurious or difficult to eradicate, and thus is named in the Noxious Weeds Act.

Exercise

Send for the weed bulletins and the Noxious Weeds Act published by the Department of Agriculture of your province. What weeds are listed as noxious weeds?

Classes of weeds. Weeds are classified according to the length of time they live. Annuals are weeds that complete their growth in one year; biennials live for two years, producing seed the second year; perennials continue to grow for many years. Winter annuals are annual weeds, but their seeds begin to grow in the fall, usually forming a small flat rosette; the young plants live through the winter and begin to grow rapidly very early in the spring.

Damage done by weeds. Weeds reduce the yield of field and garden crops by robbing the soil of moisture and plant food, and by crowding out or shading less hardy, or slowly growing plants. They injure the quality of farm produce; weed seeds lower the grade and increase the dockage in grain crops; French-weed taints the flavour of dairy products; burs reduce the quality of wool; and cockle seeds in wheat give a bad taste to flour. They provide egg-laying places for injurious insects and are "hosts" to harmful plant diseases. Noxious weeds are also expensive to eradicate. When a farm becomes infested with weeds, its value is greatly reduced.

How weeds are spread. Weeds are dispersed by many natural devices and, too often, by carelessness on the part of the farmers themselves. They are spread: (*a*) by wind—tufted seeds

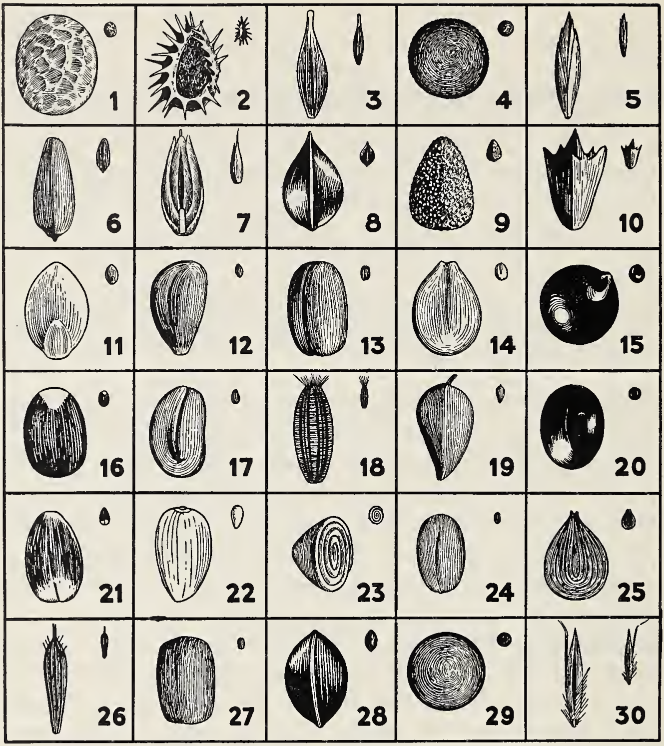


Fig. 110. SEEDS OF COMMON FARM WEEDS

1. Ball mustard
2. Bluebur
3. Blue lettuce
4. Cow cockle
5. Couch grass (spikelet)
6. Canada thistle
7. Darnel
8. Dock
9. Field bindweed
10. Great ragweed
11. Green foxtail
12. Gray tansy mustard
13. Hare's ear mustard
14. Hoary cress
15. Lamb's quarters
16. Leafy spurge
17. Pepper grass
18. Perennial sowthistle
19. Poverty weed
20. Redroot pigweed
21. Russian pigweed
22. Russian knapweed
23. Russian thistle
24. Shepherd's purse
25. Stinkweed
26. Dandelion
27. Tumbling mustard
28. Wild buckwheat
29. Wild mustard
30. Wild oats

FIG. 111. Great ragweed.*

FIG. 112. Tumbling mustard.

such as dandelion and thistles, tumble weeds such as Russian thistle and tumbling mustard; (*b*) by water—most seeds are oily enough to float; (*c*) by birds and other animals—in mud on their feet or in burs clinging to their coats; also, many seeds are not digested and are spread in manure; and (*d*) by man—in grain, grass, garden, and legume seed, by railways, by machinery such as stoock wagons, threshing machines, etc., and in the straw packing of settlers' effects.

Many of our worst weeds are of foreign origin and have been introduced into Canada by the importation of dirty seed or by immigrants who have used weedy straw for packing.

The identification of weeds. A good way of becoming familiar with weeds, is to learn their general characteristics by families. The members of each plant family have many distinguishing marks in common, and once the identity of an unknown weed has been traced to the proper family, complete identification is comparatively easy. For the student, written descriptions should

*The weeds illustrated on pages 177-186 with the exception of Figure 111, have been re-drawn by permission of the Department of Agriculture, Alberta, from *Farm Weeds*, published by the Searle Grain Co., the Home Grain Co., and the Midland and Pacific Grain Corporation.

Fig. 113. Frenchweed or stinkweed.

Fig. 114. Wild mustard.

be very brief, and a definite procedure should be followed in tabulating observations. The following outline describing stinkweed will serve as a model.

Name—stinkweed or Frenchweed.

Family—mustard.

Growth—annual or winter annual, reproduced by seeds.

Root—fibrous.

Stem—erect, smooth, branching from two to twenty-four inches high.

Leaf—wavy edge, upper leaves stalkless clasping stem with arrow-shaped base, lower leaves have stalk.

Inflorescence—a raceme, indefinite, *i.e.* the plant blooms and produces seed from early spring to late fall.

Flower—small, white, four petals or cross-shaped.

Seed—small, folded, purple with a metallic sheen, ringed, borne in pods that are winged with a notch at the top.

Wild mustard. Mustard family; annual, reproduced by seed; root—fibrous; stem—erect, branching, with stiff hairs pointing downward, purple at the junction of leaves and branches; leaves—deeply toothed; inflorescence—raceme; flower—bright yellow, showy, four petals; seeds—small, round, reddish-brown, pitted, borne in long knotty pods having a short spike at top.

FIG. 115. Wild oats.

FIG. 116. Russian thistle.

Wild oats. Grass family; annual, reproduced by seeds; root, stem, leaf, and inflorescence closely resemble cultivated oats; seeds—more slender than cultivated oats, white, black, gray, brown, horseshoe-shaped mouth at base which is surrounded by stiff bristles, a twisted awn bent at right angles.

Russian thistle. Pigweed family; not a thistle; annual, reproduced by seed; root—small, tap, easily broken off in the fall; stem—branching, dark green when young, striped with red as matures; leaf—long, needle-shaped, pointed, drops off soon after seed is produced; inflorescence—flowers borne singly in the axils of the leaves; flower—small, greenish, inconspicuous; seed—small, 50,000 per plant, olive green, conical, coiled like a snail shell, papery covering; in the fall the plant curls up, breaks from the root, and may be blown for miles, scattering seed.

Perennial sowthistle. Daisy family; perennial, reproduced by seed and deep-running rootstocks, rootstocks have been found with six plants on a two-inch length, others have measured eighteen feet long; stem—from one to five feet tall, hollow, filled with bitter milky juice, few leaves, branching at top; leaf—long, deeply cut with points turning slightly backwards, filled with bitter milky juice, clasps stem with arrow-shaped base; inflorescence—dozen or more flowers in groups; flower—large, bright yellow, composite, *i.e.* com-

Fig. 117. Perennial sowthistle.

Fig. 118. Russian knapweed.

posed of small flowers called florets; seed—small, slightly bent, dark reddish-brown, deeply ribbed lengthwise and cross wrinkled, topped by fine, silky, spreading hairs, which act as an efficient parachute to carry seed long distances.

Canada thistle. Daisy family; perennial, reproduced by seeds and deep-running rootstocks; stem—erect, from two to four feet high; leaf—narrow, twisted, sharp spines; inflorescence—dozen flowers or more in groups; flower—white, pink, or purple, compound or composite, staminate and pistillate flowers on different plants, staminate flowers spherical, pistillate oblong; seed—small, light

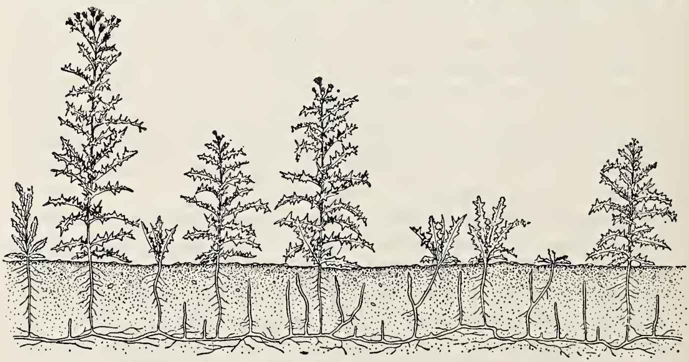


Fig. 119. Canada thistle, showing the production of new plants from underground stems or rootstocks.

Fig. 120. Field bindweed.

Fig. 121. Leafy spurge.

brown, slightly bent, flattened, angular, collar at top bearing fine silky parachute.

Russian knapweed. Daisy family; perennial, reproduced by seeds and hardy, deep-growing creeping root system; stem—rough, woody, covered with a fuzziness or nap, branched, two feet high; leaves—narrow, pointed, notched; flowers—numerous, rose-purple florets in a head; seeds—small, white, hard, and smooth.

Field bindweed. Morning glory family; perennial, reproduced by seeds and extensive, deep-growing, creeping rootstocks; stems—numerous, twining, smooth; leaves—small, arrow-head-shaped, slender stalked; flowers—similar to morning glory flowers but smaller, pink, funnel-shaped, over one inch across; seed—three to four in a two-celled capsule, one-sixth inch long, dark brown, roughened, one face convex and the other angled.

Leafy spurge. Spurge family; perennial, reproduced by seeds and deep, woody rootstocks; leaves and stems rather pale green, when broken exude a thick white sap; leaves—small, lance-shaped; flowers—small, in clusters, surrounded by yellow-green leaf-like parts.

Hoary cress. Mustard family; perennial with deep, branching roots; stem—erect; leaves—bluntly pointed, very finely toothed or wavy edge, upper leaves are stalkless and clasp the stem with an arrow-shaped base; flowers—small, white, cross-shaped, in clusters; seeds—small, folded.

Toad flax. Figwort family; perennial, reproduced by seeds; root—deep, persistent; stem—erect, slender; leaves—numerous, lance-shaped, stalkless; flowers—fairly large, in clusters, pale yellow

with orange lips, two-lobed corolla, the two parts separating or opening when gentle pressure applied at the sides; seeds—small, winged, dark-coloured, flat, round, surrounded by a circular wing.

Prevention of weeds. From every standpoint it is better to prevent the spread of weeds than to spend time and money eradicating them after they have established themselves on our farms. The following suggestions, if put into practice, will help to prevent the spread of weeds.

FIG. 122. Hoary cress.

(1) Sow only clean sound seed. Time occupied in putting seed grain through a fanning mill is well spent. (2) Carry out the provisions of the Noxious Weeds Act, which requires threshing machines and wagon racks to be well cleaned before being moved from one location to another. This is a wise precaution with all farm machinery. (3) Use only clean feed. When feed is dirty, it should be crushed to destroy the germinating power of the weed seeds. (4) If you are using weedy straw for bedding, do not spread manure until it is well rotted. (5) Keep the weeds along your roadsides and fences under control; sow these areas to brome or crested wheat grass. (6) Know the noxious weeds—seeds and plants. Be able to recognize the enemy. (7) Begin the attack early. Know the cultural practices recommended. Rotate crops where grasses and legumes grow satisfactorily. These two kinds of crops are valuable aids in controlling annuals and hold most perennials in check. Avoid causing soil drifting. (8) Try to secure the co-operation of everyone in the community. Farmers cannot keep their farms clean if their neighbours' fields are weedy.

Eradication of weeds. Each class of weeds must be attacked in a different manner because methods that destroy certain weeds encourage the growth of others. In each case it is also necessary to start in infested fields with the objective, the removal of the weeds present.

Annuals. Annuals are one-year weeds. The more the plant itself grows, the nearer it approaches the time when natural causes will remove it from the field. It is the seeds that are troublesome, because they often lie dormant in the ground for many years. As long as there are seeds in the soil, weeds may appear at any time and crowd out and destroy young grain or grass crops. The attack, therefore, must be directed against the seeds of annual weeds.

Fig. 123. Toad flax.

The land should be cultivated quite shallow as soon as the crop is off the field in the fall to germinate seeds that are in the soil. Plants thus produced will be killed by the frost. In the spring, further shallow cultivation should be given to the soil to germinate more seeds. If the weeds are bad, the land should be summerfallowed. Cultivation is required at intervals to germinate seeds and destroy plants started by the previous cultivation. Cultivate only as necessary to avoid drying out the surface of the soil.

When the land is weedy, sowing wheat and other crops at a heavier than the normal rate gives the crop an advantage, and tends to reduce the growth of weeds and the number of weed seeds produced. For wild oats, which ripen and shell out very early in the season, early maturing crops are useful. When oats to be used for green feed, fall rye, or an early variety of barley

FIG. 124. Spray equipment for large-scale destruction of weeds by means of 2,4-D. (Photo from L. H. Shaw)

are sown heavily in an infested field, the crop will be ripe and ready to cut early enough to catch the seeds before they scatter. Weeds that have gone to seed should be mowed and, when dry, raked into piles and burned. It is much more effective, however, to prevent weeds from seeding. Sowing the land down to a perennial hay or pasture crop for a few years helps to control wild oats and certain other annuals. Sheep and other live stock, when pastured on summerfallow, eat a great many weeds, and thus do much to stamp them out. Applications of commercial phosphate fertilizers stimulate the growth of crops and thus enable them to keep ahead of the weeds.

Many annuals can be controlled by the use of 2,4-D, a hormone weed killer that produces a twisted growth in broad-leafed plants and finally death. It has been used successfully in lawns, and corn and grain fields. When first introduced, it was thought that 2,4-D readily destroyed all broad-leafed plants. However, it has been found that about fifty per cent of broad-leafed plants are partially resistant. Generally speaking, the results of 2,4-D

on perennials (leafy spurge, Canada thistle, etc.) have been disappointing, although dandelions quickly succumb. It is most effective when used during the active growing season. If carelessly handled, 2,4-D may cause serious damage, since most vegetables and flowers are readily killed by it. However, it is an effective herbicide. It is for sale both as a liquid and a dust; further information on 2,4-D can be secured from your local agricultural representative.

Fig. 125. Redroot pigweed.

Winter annuals and biennials. Winter annuals and biennials may be eradicated by much the same methods as annuals. It is necessary, however, to follow the early fall cultivation by another just before freeze-up to destroy young plants that would otherwise winter through. In summerfallowing to kill stinkweed, the plants should not be given time to produce seed between the intervals of cultivation. Why? Ploughless summerfallows induce the largest number of weed seeds to grow and have value in the control of annual and biennial weeds. Unfortunately, cultural methods are not always effective in controlling them. Barley tends to crowd them out if the weeds are not too numerous. Hay and pasture crops also have value in this connection. Hurrying the grain crops by the use of commercial fertilizers helps them to get ahead of the weeds.

Perennials. Perennials must be attacked by methods entirely different from those outlined for other weeds. In this case, it is with the plants themselves that one should be concerned. The more they grow, the stronger they become.

In dealing with Canada thistle, sowthistle, and couch grass, the attack might begin in the fall by ploughing deep enough to expose the rootstocks to the sun and wind. The soil should then

be well cultivated until freeze-up and again in the spring. A thoroughly black summerfallow is required when the weeds have infested large areas. The fallow should be ploughed four or five inches deep early in July and kept black until freeze-up. If the development of leaves is prevented, the plants become weakened and finally die. Cultivation may be necessary as often as once a week for the first few weeks. However, the black summerfallow will leave the land without any trash cover and disposed to drift; the last cultivation therefore, should work the soil into a lumpy condition. Only implements that will not clog or drag the roots to clean parts of the field should be used. The duckfoot cultivator and the rod weeder (Figure 74) are recommended for thistles, and the disk and the spring-tooth harrow for couch grass. The summerfallow may be pastured during the early part of the summer. Sheep readily eat sow-thistle and, being very close nibblers, are effective in preventing the formation of leaves.

FIG. 126. Couch grass.

Intertilled crops, such as corn, roots, etc., may be planted, but should be kept well cultivated. Small patches of weeds should be hoed or dug up as soon as they are discovered and small areas and even large patches of certain perennial weeds can be economically sprayed with 2,4-D. However, there is a great variation in the amount that should be used and the stage of plant growth when this chemical is effective. Sodium chlorate is the most expensive and the most effective perennial weed killer, but it renders the soil barren for at least two years. Its use

therefore, is limited to small patches only. (It is important to know that clothing, plant material, wood, or organic dust on which a solution of sodium chlorate has dried are very readily ignited by a spark, heat, or friction.) Heavy stands of alfalfa and perennial grasses are effective in crowding out weeds. Crop rotations including brome grass and sweet clover are helpful in checking many perennial weeds.

Exercises

1. Give as many examples as you can of annual, winter annual, biennial, and perennial weeds.
2. Outline, step by step, the procedure to be followed in the eradication of a winter annual weed.
3. Do you consider the fanning mill to be useful in the control of weeds? Give a reason for your answer.
4. Make a complete summary of all the methods that are used to eradicate and control weeds. In each case state the class, and give several examples of weeds against which these methods are effective.
5. Consult publications, such as *Guide to Farm Practice in Saskatchewan*, to learn the procedure to be followed when methods of controlling the pale western cutworm, for example, conflict with cultivating for a black summerfallow.
6. Discuss weed control in relation to soil drifting and moisture conservation. See Exercise 3, page 16. See also page 37.
7. Examine as many of the noxious weeds in your district as you can. Write a description of each as suggested for stinkweed. Make descriptive drawings of characteristic parts.
8. Try to recognize the weeds which you have studied when you see them in the fields or along the roadside.
9. Send for a copy of the book *Farm Weeds in Canada*, for sale by single copies at the Office of the King's Printer, Government Printing Bureau, Ottawa, at $2.00. It is beautifully illustrated in colours.
10. Barberry (with the exception of the Japanese barberry) has now been added to the list of noxious weeds. Why?
11. Discuss losses due to weeds. Consider, in addition to the losses outlined on page 175, the cost of extra cultivation made necessary by weeds, the extra twine and threshing required, the freight paid on weed seeds shipped in dirty grain, etc.
12. "Formalin delays germination of the seed and emergence of the crop. Dust treatments for smut actually hasten germination

and emergence." Discuss the foregoing statement in relation to the control of weeds in a growing crop.

13. What seeds can be controlled by chemicals? Under what conditions are weeds most advantageously controlled by this method?

Projects

1. Prepare and mount a collection of noxious weeds common to your district. For this purpose secure two boards, large enough to cover the plants. Fasten them together at one end by means of straps. Select perfect and representative specimens of weeds, including the roots. Allow them to wilt slightly, then spread them flat on sheets of blotting paper or five or six sheets of newspaper or wrapping paper. Arrange all parts of the plant in the natural position. Cover them with paper and press them between the boards. The pressure should not be heavy enough to crush or bruise the stems. Once a day remove the covers for a few minutes to air the plants and prevent them from becoming mouldy or discoloured. Re-arrange any parts which seem to be out of place. Leave the plants in the press until they are thoroughly stiff and dry. Mount them on stiff cardboard by means of thin strips of adhesive tape or paper.

2. Make a collection of weed seeds. Place the seeds in small bottles, and mount the bottles on cardboard.

3. Make a survey of your community to find out which of the weeds listed in the Noxious Weeds Act are common there. Arrange to have a discussion on the various sections of the Act. Note particularly such sections as those dealing with the responsibility of owners and occupants of land in controlling the spread of noxious weeds; the appointment and duties of weed inspectors; the cleaning of wagon racks and threshing machines; the disposal of screenings containing noxious weed seeds; the penalties provided for inspectors who neglect their duties, and for persons who obstruct inspectors or fail to carry out the orders of the inspectors.

4. Watch newspapers and farm magazines for announcements about conventions or other meetings called for the discussion of control of weeds. Watch also for notices about successful control methods; post worth-while items on your class bulletin board.

5. Helicopters and other types of aircraft are being used increasingly for large scale spraying of pesticides on crops and weeds. Watch for developments. What are the advantages of this method? Are there disadvantages?

CHAPTER 9

PLANT DISEASES—BACTERIA AND FUNGI

Each year, crops of all kinds are seriously damaged by plant diseases. In Canada the annual loss due to grain diseases alone amounts to from ninety to a hundred million dollars. It is exceedingly important therefore, that every farmer and gardener should know the cause, appearance, and life history of the diseases that may destroy his grain, vegetable, or fruit crops. He should be familiar with the most effective and the cheapest methods of prevention and control.

The cause of plant diseases. Disease may be defined as a condition that prevents the normal functions and development of a plant (or an animal). Wounds, drought, poor soil, or other unfavourable conditions that tend to weaken a plant and reduce its power of resistance, make it easier for a disease to establish itself in the plant. These factors are directly responsible for some diseases, but many other plant diseases are caused by low forms of plant life called *bacteria* and *fungi*. Bacteria and fungi are *dependent;* that is, they have no chlorophyll and are unable to manufacture food for themselves, as other plants do. Their sustenance is secured from the *host plants* or animals upon which they live. Some of them prey upon living plants and are, therefore, called *parasites;* the rusts and smuts of grains are examples of these. Others, known as *saprophytes*, grow upon dead plant material; the rot fungi that cause wood to decay are saprophytes.

Bacteria. Bacteria (singular, bacterium) were discovered in 1695 by Leuwenhock, when he invented a microscope powerful enough to see them. As bacteria are the smallest living organisms (about one fifty-thousandth of an inch in diameter), it is necessary to magnify them about a thousand times before they become visible.

Bacteria reproduce by division. The bacterium first lengthens; then a partition forms across it; finally, it separates into two new bacteria. This process occupies about half an hour. Calculate the number that might be produced from one bacterium in half a day. Diseases caused by bacteria thus may spread rapidly. Fortunately, however, most bacteria are not harmful. Bacteria in milk, in the soil, and on the roots of legumes play an important part in agriculture; they are discussed on pages 296, 21, and 92.

FIG. 127. Bacteria magnified over 1000 times.

Fungi. Examples of fungous plants are moulds, mushrooms, toadstools, puff-balls, woody shelves or brackets that grow on trees, and the organisms that cause rusts, smuts, mildews, and many other plant diseases. These plants do not contain chlorophyll, and, therefore, cannot manufacture food for themselves. They subsist by sending a mass of fine threads or *mycelium* (plural, mycelia) into the substance upon which they are living. The mycelia absorb the food material required. Fungi reproduce by microscopic bodies called *spores.*

Occurrence of bacteria and fungi. Bacteria and the spores of fungi are always present in the air. Fortunately, most of the fungi, like the bacteria, are harmless. They all require food, moderate warmth, moisture, and air, and under favourable conditions they develop very rapidly.

Bacterial and fungous diseases are spread by many

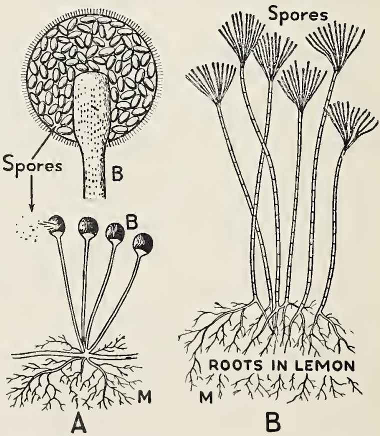


FIG. 128. Two fungi. A, bread mould; B, lemon mould. Notice the mycelia (M); the spore cases (B), and the spores. All are very greatly magnified.

agencies. In some instances (blackleg of potatoes, root-rots of cereals), the bacteria or fungi live in the soil and attack susceptible plants when they appear. Wind, water, insects, birds, farm implements, manure, nursery stock, and seed grain and vegetables are effective agencies in spreading a large number of plant diseases. Few, if any, crops are immune. Some diseases affect only one part of a single species of plants, but others are more general in their attack and infect a large number of different kinds of plants.

Cereal rusts. There are several rusts that attack cereals—leaf rust of wheat; crown rust of oats; dwarf leaf rust of barley; stripe rust of wheat and barley; and stem rust of wheat, oats, and barley. In Canada, stem rust is the most destructive. The extent of the damage caused in the past by this plant disease is difficult to realize. "In 1916, one of the worst years of rust epidemics, the losses were equal to the value of the entire mineral production of Canada in 1922, $183,000,000." The epidemic of 1935 was almost as severe as the one of 1916, and destroyed no less than 85,000,000 bushels of wheat.

The black or stem rust of wheat. There are many kinds or forms of stem rust; black rust is caused by a parasitic fungus that attacks principally the stems of wheat plants. Damp, cloudy, windless days give the spores of the fungus a good opportunity to germinate and infect the plants; and when infection has taken place, bright, hot weather promotes the rapid development of the rust organism inside of the plant so that it produces spores more quickly. Winds help to disperse the spores rapidly, but they tend also to dry the plant and prevent infection. Dry, cool weather is unfavourable to the germination of the spores, and helps to prevent the spread of the disease.

The rust fungus feeds upon the juice or sap in the wheat stem. As a result, the heads are starved, and small shrunken kernels are produced. Seed from a rusted crop will germinate, if not too shrunken, and will produce a rust-free crop. Rust is transmitted only by spores, but badly shrunken seed should not be used.

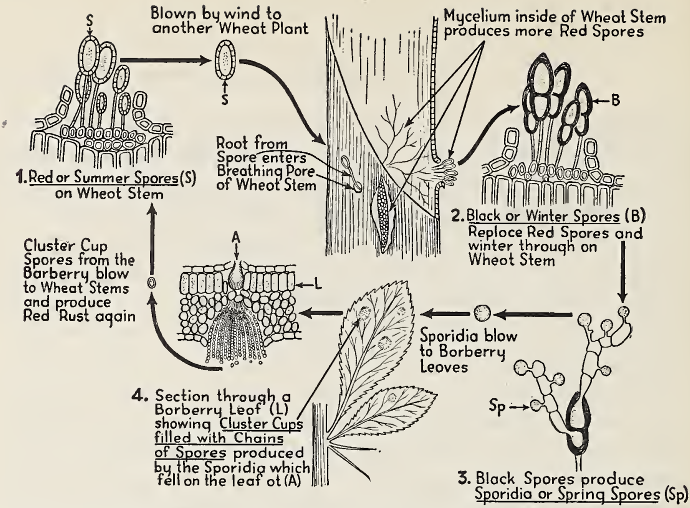


FIG. 129. Diagram illustrating the stages in the life history of the black or stem rust of wheat, as seen through a microscope. Follow the arrows.

Rust appears first about July, when small red openings appear on the stems of the wheat. Under an ordinary microscope these tiny slits are seen to be filled with hundreds of red spores. These are the summer spores, microscopic, red, thin-walled, one-celled bodies. They are easily detached from the eruption in which they appear, and may be blown to other plants by the wind. When a red spore falls upon the stem or the leaf sheath of a wheat plant, it germinates if a film of moisture is present on the plant for a few hours. A very minute *germ tube*, or root-like process, penetrates the stem through a breathing pore. The germ tube grows rapidly and soon branches into a mass of threads, or a mycelium. Within a week or less after a red spore falls upon a wheat stem, new red or summer spores burst through the epidermis of the wheat stem. These, in turn, are blown to other wheat plants, causing new infections. They may travel great distances in a day, and carry the disease to wheat fields hundreds of miles away.

After some days, when the wheat plants begin to ripen and the food supply in the stems is reduced, the rust mycelium ceases to produce red spores, and forms black spores instead. The black

spores are the winter stage of the fungus; they are two-celled, thick-walled, and packed with food. They remain dormant on the straw and stubble during the winter months. In the spring, the winter spores germinate, and each cell produces four small spores known as *basidio-spores* or *sporidia* (singular, sporidium). The sporidia are blown by the wind to the leaves of the barberry, the only plant upon which they are known to live. The common barberry is the chief species subject to infection.

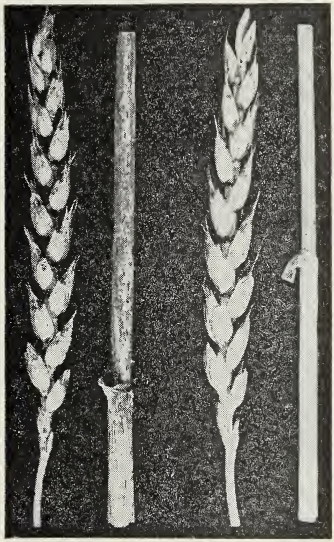


Fig. 130. Illustrating how new wheat varieties reduce losses due to plant diseases. Marquis, left, and Apex, right, under severe rust conditions in 1935 in south-eastern Saskatchewan. (Photo from University of Saskatchewan)

When a sporidium falls upon a barberry leaf, it germinates and gives rise to a mycelium, which spreads through the leaf. On the surface of the leaf, small round structures called *pycnia* are produced. (See Figure 129.) The pycnia produce *pycniospores* and exude them in a sweetish nectar. Insects carry the nectar and the pycniospores from one pycnia to another. Finally, small, circular, cup-like clusters, filled with chains of yellow or orange spores, appear on the underside of the barberry leaf. These spores are known as *cluster-cup spores.* The cluster-cup spores from the barberry are then blown back to wheat plants, where they germinate and grow, thus completing the life cycle of the rust fungus and producing new outbreaks of the disease.

The leaf rusts of cereals, and the crown rust of oats, have life histories similar to stem rust.

Control of rust. Since rust is not spread by seed, the only means of control are preventive measures, such as the following:

1. The eradication of the barberry. The United States spends large sums of money for this purpose. In Canada, barberry has been placed on the noxious weeds list.

2. Using early maturing varieties of grain, preparing the best possible seed-bed, sowing the crops as early as possible in the spring, etc. By such means the crop is encouraged to ripen before the rust season. Once the grain is mature and plump, the disease is powerless to damage the kernels.

3. Applying sulphur dust to the standing grain, before infection and later at intervals until the crop begins to ripen. This is an effective but expensive measure.

4. The development of new, rust-resistant varieties. Susceptible varieties, such as Marquis and Reward, have disappeared from the wheat fields. More than a dozen hardy, rust-resistant varieties, such as Thatcher, Apex, Regent, etc., have been developed. The Durum wheats also possess a high degree of rust resistance.

Flax and sunflower rusts differ from cereal rusts in that all spore stages develop on the one host plant. It is, therefore, necessary in these cases to plough under or destroy all crop residues when outbreaks occur. To prevent flax rust, it is advisable not to sow flax two years in succession on the same piece of land.

Exercises

1. Watch for accounts of rust research in Canada. In 1950, it was reported that new strains of rust were threatening the present rust-resisting wheat varieties.

2. From the eruption on the stem of a wheat plant scrape off some red or black spores, and prepare a microscope slide. Be careful not to remove too many spores. (See page 64 for directions for the preparation of the slide.) Slides of the four stages of rust may be obtained from firms supplying biological or agricultural equipment; but slides of the red or black spores may easily be prepared, as above.

3. Make drawings of a red spore, a black spore, a black spore forming spring spores, and a cross-section of a barberry leaf showing

Fig. 131. The smuts of wheat. From left to right: four heads infected with bunt or covered smut; a healthy head; and a head infected with loose smut. (Photos from Dominion Laboratory of Plant Pathology, Winnipeg)

pycnia and cluster-cups. Arrange them in a circle to show the life cycle of the rust fungus. Name all the parts.

Project

About the end of June, plant some wheat in boxes or in flower pots. Then in July, when the plants are a good size, secure some red spores from the stems of wheat in the field. Rub the spores on various parts of the stems and leaves of the wheat in the boxes. Remember, spores will not germinate unless they are in contact with a film of moisture long enough for the germ tube to enter the plant. Wet your plants by rubbing them lightly with dripping fingers. Then apply the spores. Make a funnel of several thicknesses of newspaper, and wet it thoroughly. Invert the funnel over the pot, and tie the open end tightly around it. Keep the paper wet for a day, then remove it. In this way you should secure an outbreak of the disease in circumstances in which you may closely watch its development. Try infecting barley, oats, and rye with rust from the wheat.

FIG. 132. The smuts of barley. Left, a head infected with covered smut. Centre, a healthy head. Right, a head infected with loose smut. (Photo from Dominion Laboratory of Plant Pathology, Winnipeg)

Loose and covered smut of wheat, oats, and barley. Smuts are caused by certain fungi, and head the list of seed-borne killers. They reduce the value of Canadian grain crops by many millions of dollars annually. While outbreaks of rust are usually confined to the stem, smuts affect the seed. All varieties of cereals are more or less susceptible to loose and covered smuts.

The covered smut of wheat, also called bunt or stinking smut, is readily detected in bins of grain by its characteristic odour. During the summer, while the crop is growing, the smut fungus also grows within the wheat plant. Later, what should become the kernels develop into spore packages called bunt balls, which are filled with millions of spores. At threshing time the separator breaks the bunt balls, and the spores scatter. They become lodged in the creases and in the woolly ends of healthy kernels. There they remain dormant until spring. If seeds carrying spores are planted, the spores germinate and infect the seedlings of the new crop with their mycelia; thus the fungus is reproduced.

The loose smut of wheat and barley destroys the entire head, leaving nothing but the central stalk, which is covered with fine, black, loose spores. These are blown to the flowers of other plants, thus spreading the disease. This fungus passes the

winter deep in the seed, and is, therefore, more difficult to destroy than the covered smut.

Control of smut. The covered smuts of wheat, oats, and barley, and the loose smut of oats, may be controlled by killing the spores with formalin (formaldehyde) solution or dry chemical dusts. The chemical dust method is replacing the use of formalin on many farms.

One method of treating seed with formalin is to pile the grain on the floor of the granary and thoroughly sprinkle it with formalin solution (1 pint of formalin to 40 gallons of water). The pile should be stirred continuously while the sprinkling is being done to ensure every kernel being moistened. The seed is then covered for two hours, after which it is spread out to dry. The formalin solution treatment is effective in controlling the covered smut of wheat and barley and the smut of oats. Occasionally formalin may injure the seed.

FIG. 133. The smuts of oats. Left, a head infected with covered smut. Centre, a healthy head. Right, a head infected with loose smut. (Photos from Dominion Laboratory of Plant Pathology, Winnipeg)

Dust treatments have resulted in a great advance in seed treatment by making it possible to treat the seed, days and even weeks before seeding. For covered smut of wheat, copper carbonate dust is recommended. Ceresan (ethyl mercury phosphate) and similar dusts control covered smuts of wheat and barley and the smuts of oats. The seed should be well coated; a

shovel may be used for this purpose but a dusting machine is better. Usually a stronger germination is obtained with dust treatments than with formalin; dusts do not injure the seed. The dusts however, are poisonous and must be used with care.

It is strongly recommended that all seed wheat, oats, and barley be treated for smut before being sown.

The loose smuts of wheat and barley are more difficult to deal with but fortunately they are not very common in this country. As the spores winter deep in the grain and not on the surface, it is necessary to subject the seed to treatment in hot water. This consists in soaking the seed for four hours in water at ordinary room temperature, 70° Fahrenheit, for two minutes at 120° Fahrenheit, and for ten minutes in water at 129° Fahrenheit. It is more satisfactory however, to change the seed when it is known that seed on hand is infected.

For smut of corn there is no control. Rye smut may be lessened by treating the seed with formalin.

> In a course in agriculture for High School students, the chief objective should be an understanding and appreciation of what agriculture is; of the work, problems, and skill of the farmer; of the contribution of science to the production of crops and live stock; and of the importance of agriculture to Canada and the world.
>
> Therefore, in a chapter such as this, it should be understood that, while the student should know something of the methods available, detailed formulae are given, not to be memorized, but for reference only.

Root-rots of cereals. These diseases attack the roots and lower parts of the stems of wheat, oats, and barley. Some are difficult to identify; and certain types cause considerable damage.

Common root-rot is of widespread occurrence and affects all cereals and many grasses. Browning root-rot appears chiefly in summerfallow crops of wheat.

Take-all, which affects wheat principally, is a type of root-rot. It is caused by a fungus that lives in the soil. Scattered single plants or patches of the crop may be attacked. The roots and the lower parts of the wheat plants at first become dark brown or black, and later are completely destroyed. Affected plants are stunted and bleached at heading time. The heads contain shrunken kernels or are empty. Control lies in refraining from sowing wheat a second year on affected land. Rotations may be modified to accomplish this. Oats, flax, sunflower, sweet clover, and potatoes are not attacked.

FIG. 134. A corn plant infected with smut. (Photo from Dominion Laboratory of Plant Pathology, Winnipeg)

The following symptoms indicate various other types of root-rots. The plants bleach prematurely. The lower parts of the plants and the roots become brown. The plants have dark lesions on the bases of the stalks, and they ripen late. In some types, the lower leaves of the young plants turn brown and die. The heads may be empty.

Control of the various fungi causing root-rots consists in: (1) using only the best seed, avoiding shrivelled or discoloured grain; (2) sowing the crop early; (3) sowing the seed not more than two or three inches deep; (4) adopting suitable crop rotations; (5) applying phosphatic fertilizers to the soil—this increases the crop's resistance to attack; (6) in the case of common root-rot, the treatment of seed with a mercuric dust frequently has some value.

Potato diseases. There are many diseases which affect potatoes. The student who intends to grow potatoes should not be content with the following brief discussion, but should study carefully several of the government bulletins.

Fig. 135. Rhizoctonia disease on potatoes, showing earth-coloured spots. (Photo from *The Grain Growers' Guide, Ltd.*)

Rhizoctonia (black scurf) is a very destructive potato disease. It is caused by a fungus that winters on the potato tubers and in the soil. It is identified by a closely curled appearance of the leaves at the top of the plants and small black spots on the tubers. The spots look like dirt, but they cannot be washed off.

Common scab is a prevalent disease, caused by a fungus that winters on the tubers or in the soil. The skins of the diseased tubers become rough and pitted. This disease does not greatly reduce the yield, but causes heavy loss because scabby potatoes are not very saleable.

Bacterial ring-rot is becoming increasingly prevalent. The symptoms are: the plants wilt and turn yellow, and brown rot more or less confined to rings appear in the stem end of the tubers. The rot winters in the tubers or sacks. Control: use only seed potatoes that have never been in contact with the disease; plant certified seed potatoes; thoroughly disinfect bins and implements.

Fig. 136. Common scab on a potato tuber. Watch for signs of scab in your own patch.

Blackleg of potatoes. Blackleg, is one of the most destructive potato diseases in Western Canada. It is caused by bacteria which winter in diseased tubers and are spread by them.

FIG. 137. The potato plant on the left is healthy; the one on the right is affected with blackleg, a very destructive potato disease. A good gardener watches his potato patch for signs of disease. Diseased plants should be pulled up and burned as soon as they are noticed.

The disease is also spread by an insect known as the seed-corn maggot. The bacteria pass through the different stages of the insect. When the adult, which is a fly, lays its eggs on or near pieces of seed potatoes, the seed pieces are inoculated with the black-leg organism.

The disease affects the tops of the potato plants as well as the tubers. The following symptoms aid detection: The foliage becomes yellowish-green in colour; the upper leaves become dwarfed and curled; and the plants have a drooping, unthrifty appearance. The lower parts of the stems, both above and below the ground, become rotted and dark brown or black in colour; diseased stems are easily pulled up. The tubers may have a slimy rot at the stem end, or soft, rotted conditions further within; sometimes the bacteria gain entrance through wounds in other parts of the tuber. The disease may extend through the stems in dark-coloured streaks, or may appear in a ring in the sap-conveying tubes of the tubers. Plants may be attacked at different times; young plants very often die. Missing hills and a stunted, uneven crop are good indications of the presence of blackleg.

The following measures are recommended as a means of controlling blackleg: (1) selecting seed with extreme care, avoiding seed suspected or known to have been exposed to disease in any way; (2) soaking the seed for two hours in formalin solution, or for an hour and a half in corrosive sublimate (see page 202 for proportions); (3) planting cut seed as soon as possible to prevent the seed-corn maggot fly from laying its eggs on the seed pieces; (4) roguing the crop during the summer, removing and destroying all diseased plants as soon as detected. A crop rotation is useful, because, while the disease does not winter in the soil, diseased tubers may remain in the potato plot and infect the next crop.

These and other methods of control are discussed more fully in the following section.

General control of potato diseases. Use officially certified seed. Seed potatoes may be soaked for two hours in corrosive sublimate if it is not too expensive; 4 ounces to 25 gallons of water is recommended to reduce common scab, blackleg, and rhizoctonia; or mercuric chloride, 6 ounces added to 1 quart of commercial hydrochloric acid and diluted to 25 gallons of water. An organic mercury compound, Semasan Bell, has been developed especially for potato treatment. All potatoes showing signs of disease should be discarded. The knife used to cut potato sets, if it passes through a diseased spot, should be dipped in a strong solution of formalin. During the summer, potato crops should be carefully rogued. This consists of removing and destroying all diseased plants that are detected during the growing season. Strong, vigorous, disease-free plants should be marked during the summer, and the tubers from these plants should be selected for seed. Since the fungi causing common scab and rhizoctonia winter in the soil, it is necessary to avoid growing potatoes on the same land more often than once in four or five years. A well planned crop rotation is essential for the production of disease-free potatoes. To control late blight, a disease not common in Western Canada, but extremely serious in Ontario and the specialized potato-growing areas of New Brunswick and Prince Edward Island, the leaves of the potatoes should be sprayed with Bordeaux mixture. The spores of the late blight fungus are blown from one plant to another by the wind; but when the leaves have been well sprayed, the spores are destroyed before the new plants become infected.

Preparation of Bordeaux mixture. One formula is as follows: dissolve 4 pounds of copper sulphate (bluestone) in 4 gallons of water. Mix from 6 to 8 pounds of hydrated lime in 4 gallons of water. Now add 32 gallons of water to the copper sulphate solution, and strain the lime into it. Use only wooden or earthenware vessels. Consult government bulletins for further informa-

tion. Bordeaux mixture is mentioned because it is a very effective fungicide and has been used to control many plant diseases. If lead or calcium arsenate or nicotine sulphate is added to the above mixture, it is effective against insects as well as fungi.

Bordeaux mixture is prepared in various strengths. Bordeaux 4-4-40 means 4 pounds bluestone, 4 pounds lime, and 40 gallons of water. Other strengths are $7\frac{1}{2}$-10-100 and 5-$7\frac{1}{2}$-100.

Diseases of fruit trees and bushes. The successful fruit-grower should be continually on the watch for the appearance of disease in his orchard. If discovered early, many of these diseases may be checked by pruning and burning the diseased branches. It is a much safer practice, however, to spray the trees or bushes regularly with a suitable fungicide, such as Bordeaux mixture or lime sulphur. Lime sulphur is a commercial product. It is prepared in three different strengths and is used for the control of fungous diseases of apples, pears, peaches, plums, cherries, and other fruit trees. (See page 153.) In British Columbia it was discovered that certain fruit tree diseases, such as bitter pit and corky core of apples, were caused by a deficiency of boron in the soil. An application of salts containing boron effected a correction.

Apple scab. Serious loss is caused annually by apple scab or black spot, which is the most destructive disease of apples. It is caused by a fungus which attacks the fruit, the blossoms, the leaves, and even the twigs. On the fruit, the fungus causes small greenish scabs with fringed margins. An attack on the blossoms results either in deformed fruit, or in the blossom or the young fruit dropping off the tree. Outbreaks on the leaves cause dark, irregular, velvety spots to appear on both the lower and the upper sides of the leaves and often a puckering of the surface.

The life history of the fungus is as follows: During the fall and winter, numerous tiny fruiting bodies develop on the fallen apple leaves. In the spring, as the buds are forming, these fruiting bodies produce and discharge minute spores, called *ascospores*,

which are carried by the breeze to the apple leaves. The discharge of ascospores continues during wet weather until the fall. The ascospores produce infections on the new leaves and blossoms, and these infections in turn produce summer spores or *conidia*, which cause further infections throughout the growing season.

FIG. 138. Apple scab. (Photo from Central Experimental Farm, Ottawa)

Prevention, in the case of apple scab, lies in timely, thorough spraying with such fungicides as Bordeaux $7\frac{1}{2}$-10-100 and lime sulphur to protect the leaves and the young fruit at various stages: (1) when the buds are opening, (2) when pink first shows in the blossoms, (3) when nearly all the petals have fallen, and (4) three weeks after the third spraying. In certain seasons and districts, additional sprayings, one in August for example, may be necessary.

Fire blight. In Saskatchewan, fire blight is a serious bacterial disease attacking apples and crab apples. It spreads rapidly and trees attacked may be killed back several feet in one season. The most effective control measure is the use of resistant varieties. However, pruning cankers out of the bark before blossoming time and removing severely damaged trees are also of value.

Exercises

1. Examine fallen apple leaves in the autumn to find the fruiting-bodies of the apple scab fungus. Look for "small, black, pimple-like growths." Use a magnifying glass.

2. An annual spray calendar may be obtained by fruit-growers (and others) in Ontario by addressing an enquiry to the Fruit Branch, Department of Agriculture, Toronto.

Damping-off disease. This disease is common in greenhouses and hotbeds. It is caused by a fungus that lives, for the most part, in the soil. Under favourable conditions, plants such as cabbage and tomatoes, may be attacked and killed very quickly. The development of this disease is encouraged by excessive dampness, poor ventilation, and darkness. Its control is made easier by remedying these causes. The soil may also be sterilized by live steam or formalin. Seed should be disinfected before planting, using mercuric chloride or an organic compound. If the disease appears, the plants should be watered two or three times a day, at four day intervals, with Bordeaux mixture or any other suitable fungicide.

Exercises and Problems

1. The foregoing discussions should be supplemented by reading bulletins from provincial and Dominion Departments of Agriculture.

2. It is likely that a great deal will be accomplished in the near future in the work of producing disease-resistant varieties of crops by careful selection and cross-breeding. Watch the papers carefully for announcements about new varieties of wheat and other crops.

3. Make a list of the fungicides (preparations for the control of fungi) which have been discussed. Give examples of the diseases against which each fungicide is used. Watch for new organic preparations to replace metallic compounds.

4. Methods of controlling plant diseases have been discussed in this chapter. Make a summary of these methods in tabular form; give examples of the diseases controlled in each case, and explain how each method is effective. (See also page 232 re principles.)

5. Make a collection of plant disease specimens. Mount them neatly on a card, in a frame, or in suitable bottles.

6. Try to make your study of plant diseases real by identifying the symptoms of several diseases under outdoor conditions. Look for evidence of the seriousness of plant diseases in your own community. Consult farmers and gardeners.

CHAPTER 10

INSECTS—EARTHWORMS—BIRDS—GOPHERS

Over one-half of the species of animals in the world are insects. They are so widely distributed and so numerous that it is sometimes said that we are living in the age of insects.

The characteristics of an insect. All insects have similar characteristics, so that if one is carefully studied, a good idea can be formed of all animals of this class.

Exercises

1. Obtain several grasshoppers, flies, moths, butterflies, beetles, and other insects. Living specimens may be placed under glass tumblers for observation. Closely examine each insect, and tabulate its general characteristics as follows:

Insect	No. of Legs	No. of Wings	No. of Parts to Body	Attachment of Wings and Legs	Antennae or Feelers
Grasshopper.	3 pairs	4	3	to thorax	2
Butterfly....	3 pairs	4	3	to thorax	2
Moth.......					
Beetle......					
Bee........					
Etc.......					

Do you find them to be alike in any respects?

2. Now examine a grasshopper in more detail. The three parts of the body are known as the head, the thorax, and the abdomen. To which part are the wings and the legs attached? The smelling organs are located in the antennae. The grasshopper has three simple eyes in the front of its head and two large compound eyes on either side. Notice its strong cutting mouth parts. The food tube, or *alimentary canal,* is composed of the following parts in order: an enlarged crop-like part, the gizzard, where poorly chewed food is further broken up, the digestive, and the excretory organs. Look along each side of the abdomen for a number of small openings.

These are the breathing organs or *spiracles.* The grasshopper has no lungs but has, instead, a series of fine branching tubes. Locate the hearing organs on the first segment of the abdomen. Observe the hard outer covering of the body. This forms the skeleton of the grasshopper, and, because it is on the outside of the body, it is called an external skeleton or an *exoskeleton.* In what respects are the hind legs of a grasshopper especially adapted for jumping and landing?

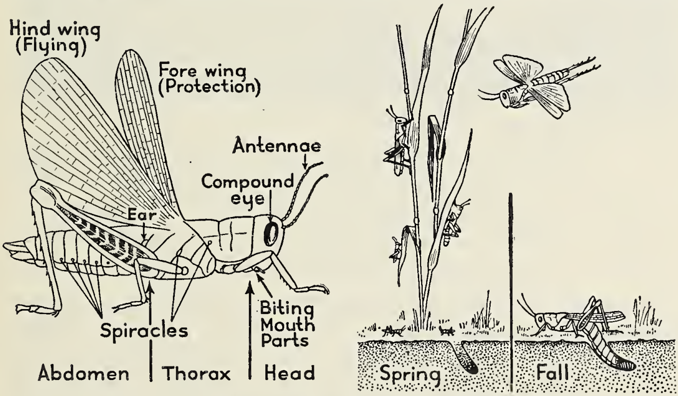


Fig. 139. Characteristics and life story of the grasshopper.

The general characteristics of the grasshopper are typical of all insects, although not all insects have four wings. An insect therefore, may be defined as an animal that has its body divided into three parts, has antennae and six legs, breathes by means of air tubes, and, after hatching from the egg, passes through a metamorphosis before becoming an adult.

The life history of insects. Metamorphosis (*meta,* change; *morphe,* form). Every insect begins life as an egg. After hatching from the egg, the insect undergoes a distinct change in form before reaching the adult stage. These changes are more pronounced in some insects than in others.

(*a*) *A typical complete metamorphosis.*—The bodies of many insects, such as butterflies, moths, bees, ants, beetles, flies, and others, undergo a complete change in form as they develop into

maturity. There are four stages of growth. The egg is laid by the adult on or near food for the larvae. The *larva* (plural larvae) hatches from the egg and does little but eat and grow. The larvae of moths and butterflies are called caterpillars. The larva of the fly is known as a *maggot*. The *pupa* (plural, pupae) is sometimes called the resting stage; when the larva has become full grown, it builds a case around itself, and during the period that it remains in this case its body is rebuilt into an adult insect. The pupa of a moth is called a *cocoon*, and that of a butterfly a *chrysalis*. The *imago* or adult insect emerges from the pupa case full grown, when the metamorphosis is completed.

(*b*) *A typical incomplete metamorphosis.*—Except that it has no wings, the body of a newly hatched grasshopper does not differ a great deal from the body of a full grown adult. The grasshopper, therefore, during its growing process does not pass through as complete a change in form as that described above. For this reason it is said to have an incomplete metamorphosis. There are three stages in its life history. The insect begins life as an egg. From the egg hatches the *nymph* or young grasshopper. The nymph *moults*, that is, sheds its skin or exoskeleton, a number of times during its growth. After the last moult, it has wings and is a complete adult. The moulting period requires practically all summer, and during the process the nymphs feed extensively. The female grasshopper lays its eggs, in small waterproof cases, on the sunny sides of grassy knolls in the fall. Crickets, bugs, dragonflies, and aphids are some other insects that undergo an incomplete metamorphosis.

The classification of orders of insects. Though the names of the common orders of insects, as outlined below, need not be memorized, they are convenient for reference in the identification of specimens.

Orthoptera—straight wings; grasshoppers, crickets.
Hemiptera—half-winged; bugs, aphids.
Coleoptera—sheath or hard wings; beetles.
Hymenoptera—membrane wings; ants, bees, wasps, sawflies.

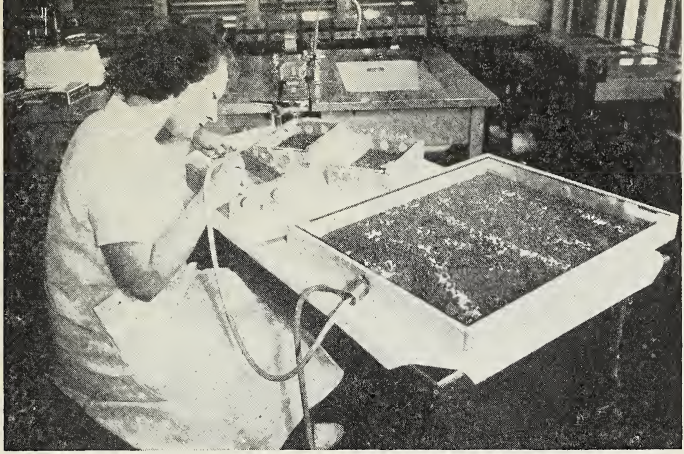


Fig. 140. This worker is engaged in a laboratory test to learn more about harmful insects in order to assist the farmer and gardener in preventing insect damage to their crops. (Photo from Dominion Department of Agriculture, Ottawa)

Odonata—lace-like wings; dragonflies.
Ephemerida—short-lived; Mayflies.
Lepidoptera—scale wings; butterflies, moths.
Diptera—two wings; flies, mosquitoes.

Beneficial insects. Many insects are beneficial and thus should be protected and encouraged to multiply. The silkworm is one of these. The tachina fly is helpful in another way; it lays its eggs on the bodies of many injurious larvae, and the young maggot, which hatches from the egg, destroys the caterpillars. The ladybird or ladybug, which is a beetle in both the adult and the larva stages, feeds upon plant lice, potato beetles, and other harmful insects that attack trees and garden crops. Carrion beetles live upon dead animal bodies.

A laboratory for the study and breeding of useful parasitic insects was established at Belleville, Ontario, in 1936.

Bees. Of all insects, bees are perhaps the most useful to man since many flowers depend upon bees for the transfer of pollen from anther to stigma. In fact, in some localities where bees are not common, gardeners must themselves pollinate their squash, melon, and similar crops.

Bees are valuable as producers of honey and wax and as distributors of pollen. The honey is produced from nectar gathered from flowers, and the wax is secreted from small pockets on the

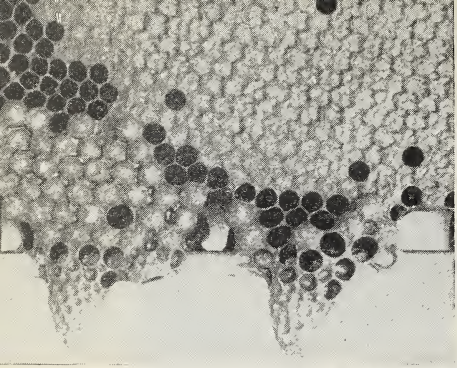


Fig. 141. Capped worker cells (upper right corner), drone cells (lower left corner of frame), and two queen cells (hanging from lower edge of frame). (Photo from Dominion Department of Agriculture, Ottawa)

underside of the abdomen. Each hind leg of the bee is provided with a tiny sac for carrying pollen.

Bees live in well organized colonies. Each colony usually consists of a queen, a few hundred drones, and thousands of workers. The queen bee is much larger and longer than the workers and is a perfect female. She lays all the eggs from which the young of the colony are produced. The workers are undeveloped females. They perform the work of the hive, such as gathering nectar and pollen, producing honey and wax, feeding and caring for the young, and protecting the hive from robber bees. The drones are the males. Only the workers sting—the drones have no stinging organs, and the queens use theirs only to destroy rival queens.

Bees undergo a complete metamorphosis. Early in the spring the queen begins to lay eggs in worker cells, which are about one-fifth of an inch in diameter. When the larvae are full grown, the worker bees cap the cells, and the young bees pass into the pupa stage. In twenty-one days after the egg is laid, a worker

Fig. 142. A worker bee (left), a queen bee (centre), and a drone (right). (All much enlarged.) (Photo from Dominion Experimental Farms Branch, Ottawa)


Fig. 143. This hive has been opened to examine the honeycomb. Notice the bees on the frames leaning against the hives and in the man's hands.

emerges. Later the queen deposits eggs in drone cells, which are approximately a quarter of an inch across. These eggs develop into drones. Finally, specially constructed queen cells are built. When the eggs laid in these cells hatch, the larvae are fed a very rich food, called *royal jelly*, which causes them to develop into queens. After the queen cells are built, the old queen and part of the colony *swarm*, that is, leave the hive. The first young queen to emerge usually destroys the other queens by stinging them. Four or five days after she emerges, the queen leaves the hive for a few days to mate with a drone, after which she returns to fulfil her function of laying eggs.

Italian bees, which may be identified by yellow bands around the abdomen, are by far the most popular kind in Canada, although there are a few apiaries of black hybrid and carniolan bees.

The care of bees. The apiary should be located in a grove of trees that will provide effective shelter from strong winds. The hives should be shaded during the hottest part of the summer days, but should also be exposed to a certain amount of sunlight. It is very desirable to have a plentiful supply of honey plants, such as willows, fruit trees, dandelions, sweet clover, red clover, alsike, alfalfa, fireweed, golden rod, etc., within two or three miles of the apiary. The primary object of the bee-keeper is to keep his colonies large and strong, and to prevent swarming. Bees usually swarm when there is a lack of food or room in the old hive. Preparations for swarming may be detected by the presence of eggs in queen cells in the brood chamber.

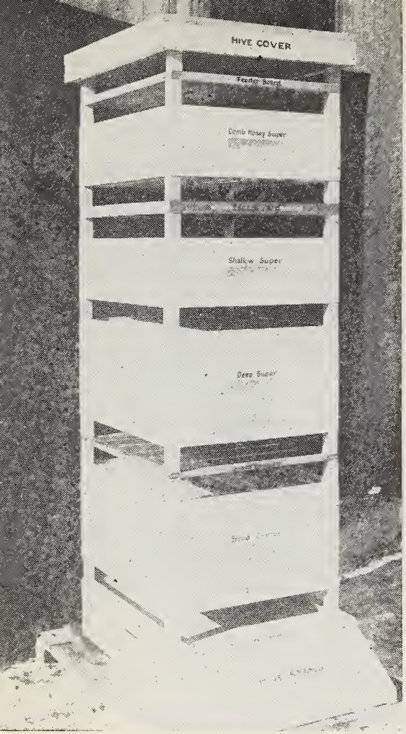


Fig. 144. The 10-frame Langstroth hive, with upper parts separated. This is the standard hive in North America at the present time. (Photo from Dominion Experimental Farms Branch, Ottawa)

The most common type of hive is the Langstroth. Each hive of this type consists of a lower section or brood chamber in which the young are raised, and upper sections, called *supers*, in which the surplus honey is stored. The supers are added as the flow of honey increases, and the queen is kept out by a queen excluder or screen through which the workers only can pass. The hives are supplied with movable frames, $17\frac{5}{8}$ inches long and $9\frac{1}{8}$ inches deep, and the honey is produced and the young are raised in hexagonal wax cells built in these frames. To make the work of the bees easier, the frames are fitted with sheets of wax upon which the pattern of the comb cells has been stamped. The bees draw this wax out to make the cells.

The hives should be examined at frequent intervals to detect disease or other unfavourable conditions. If the bees are first smoked and then handled carefully, there is little danger of being stung. To control foul brood, a very destructive bee disease, all colonies in Saskatchewan must be registered with the Bee Division, Regina. No used equipment may be imported into the province. Bee-keepers should not purchase second-hand equipment, or trade or loan equipment, without first having it examined by a qualified person to be certain that it has not been infected. Similar regulations apply in all parts of Canada. In Ontario for example, the importation of bee-keeping equipment from other provinces is permitted, provided that a certificate is supplied to the effect that the equipment is

free from disease. Such a certificate is to be supplied by the provincial apiarist of the province concerned.

Some bee-keepers winter their bees in dark, cool, well ventilated cellars or in well packed cases out-of-doors. When this is done, the bees must be supplied with food in the form of sugar-syrup, or honey. Other bee-keepers kill their bees each fall, and purchase packages of bees for a new beginning the following spring. Two popular sized packages are available—a two-pound package, containing a queen and approximately 10,000 workers; and a three-pound package, which includes an additional 5000 workers. Ordinarily, if purchased early, the two-pound packages produce as good results as the larger ones. Package bees are secured from the southern United States, and are shipped in wire-screen cages. The bees must be removed from the package immediately upon arrival, placed in a hive, and supplied with honey and combs. Under favourable conditions, the bees soon establish themselves in a hive and develop into a strong colony. The honey is marketed in the comb or extracted from it by a machine.

Bee-keeping has proved to be a profitable side-line for farmers and others. Beginners are advised to start on a small scale, with one or two hives. As knowledge and experience are acquired, the number of hives may be increased.

NOTE.—For further study of bees, send for Bulletin No. 169, *Bees and How to Keep Them*, Publications Branch, Department of Agriculture, Ottawa.

Injurious insects. Injurious insects are divided into two classes: (*a*) those with biting mouth parts, such as the cutworm, potato beetle, cabbage butterfly, grasshopper, etc., which feed upon the stems, leaves, and roots of plants; and (*b*) those which have sucking mouth parts, such as aphids (see Figures 145 and 162), leaf hoppers, etc., which bore into the plants and then suck the juices.

Each of these classes must be controlled by different methods. The insects with biting mouth parts are destroyed by stomach

FIG. 145. Plant lice or aphids on the leaves and stem of a rose. (Photo from Dominion Department of Agriculture, Ottawa)

poisons, placed on the ground or on the plants. The most commonly used poisons are lead arsenate and calcium arsenate (arsenate of lime). These may be mixed with water as sprays or used in a dry pulverized form as dusts. They are usually mixed with various proportions of hydrated lime, since they tend to burn the foliage of plants when applied alone. White arsenic is also used, but chiefly in poisoned baits. Where non-poisonous insecticides are required to treat food crops, derris (ground root of a tropical plant containing rotenone) or pyrethrum dusts are effective. The strength of various insecticides will vary with different insects. Proportions used for certain common insects are discussed on the following pages.

Stomach poisons have no effect upon insects with sucking mouth parts, since they feed only upon the juices inside the plant. Insects of this class must be controlled by contact sprays, which will destroy their bodies or fill up their breathing pores. Plant lice may be smothered by kerosene emulsion, composed of hard soap, kerosene, and water. Another useful contact spray is a tobacco extract, made by steeping 1 pound of tobacco refuse in 1 gallon of water for one hour and applying it at once. Whale oil soap—1 pound in from 4 to 6 gallons of soft water—is recommended to destroy aphids. The most commonly used contact insecticide, however, is nicotine sulphate, which may be employed alone as a spray ($\frac{3}{8}$ pints of nicotine sulphate, 2 pounds of soap, 40 gallons of water) or as dust (5 pounds of nicotine sulphate to

95 pounds of hydrated lime) or in combination sprays containing arsenicals and fungicides. Dormant oil and summer oil sprays (see page 154) are also useful to destroy aphids and other sucking insects.

The most effective general insecticide is DDT which gives spectacular results with some insects and is of little value with others. When DDT oil spray was released from planes on breeding waters of the dreaded, cattle killing blackfly, not more than one larva in a million remained alive. It has many uses in the garden and is effective for such insects as potato beetles, aphids, weevils, corn borers, leaf hoppers, cabbage worms, and others. Young tomatoes, beans, and some other crops may be injured by this insecticide, and when used on crops care should be taken to employ only preparations specified for plants. It has not yet been determined whether DDT residues on plants are poisonous. Until more is known it should not be applied to parts of crops to be used as food. DDT is available both as a dust and in wettable forms that can be used in sprays. It can be mixed safely with most other insecticides and with commonly used fungicides. When using DDT the manufacturer's directions should be carefully followed.

All insecticides (whether sprays or dusts) should be applied (1) early, before the plants have been seriously damaged, (2) thoroughly to all parts of the plants, and (3) with good pressure if possible. Hand or power machines are used. Spraying should be done when the plants are dry. Arsenical dusts should be applied on calm mornings or evenings when the plants are wet with dew, but contact dusts should be placed on the plants during the hottest part of calm days. Bordeaux mixture (see page 202) is used in certain circumstances as a basic liquid for poison mixtures, as, for example, when spraying potatoes or fruit trees.

The imported cabbage butterfly. The adult cabbage butterfly is yellowish-white, with black markings on the tip and other parts of the wing. These insects are very common, and may be seen during the summer flying over cabbage or turnip patches.

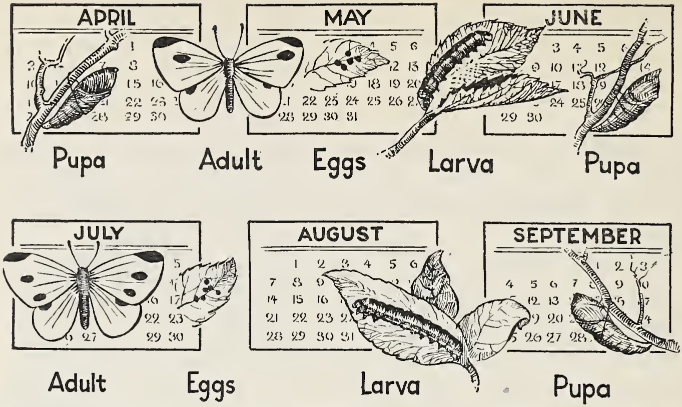


FIG. 146. The life history of the cabbage butterfly. The calendar pages tell the time of year in which the various stages of this very destructive insect occur.

The eggs are laid upon the heads of the cabbages or related plants, where they hatch in a few days. For about three weeks the greenish-coloured larva feeds upon the leaves of the cabbage plant. It then passes into the pupa stage, from which, after a three-week period, the adult emerges. The cabbage butterfly is usually *double-brooded;* that is, it passes through its life history twice (three times in Eastern Canada) in the year.

Poison sprays and dusts are effective means of controlling the cabbage butterfly. In Eastern Canada, early in the summer it is well to use (1) if spraying, 2 pounds of arsenate of lead or $1\frac{1}{2}$ pounds of arsenate of lime to 40 gallons of water and 2 pounds of soap; (2) if dusting, 3 per cent DDT or 1 part of arsenate of lead to 5 parts of hydrated lime, or 1 part of arsenate of lime to 8 parts of hydrated lime. On the prairies 1 part of arsenate of lead to 10 parts of hydrated lime makes a satisfactory dust. Likewise useful is a mixture of 1 part of lead arsenate to 10 parts of common flour. Later, as the cabbages become ready to use, a vege-

FIG. 147. The larva of the imported cabbage butterfly and the nature of its work. (Photo from Dominion Department of Agriculture, Ottawa)

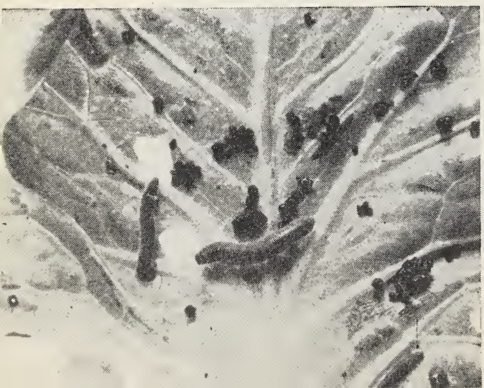


table spray, harmless to man, such as derris or pyrethrum powder should be used.

The Colorado potato beetle or potato "bug." Both the adult and the larva of this insect feed ravenously upon the leaves of potato plants, and will completely defoliate an entire patch unless they are checked as soon as they are discovered. The adults, which are not bugs but beetles, pass the winter in the ground. In the early spring they emerge, and the female lays its orange-coloured eggs as soon as young potato plants are available. The eggs hatch in a week or ten days. The larvae are full grown in two weeks, when they bury themselves in the ground to pass the pupal stage. In about two weeks more, the adults emerge from the pupa cases. They at once lay more eggs for a second generation, which by fall will have reached the adult stage.

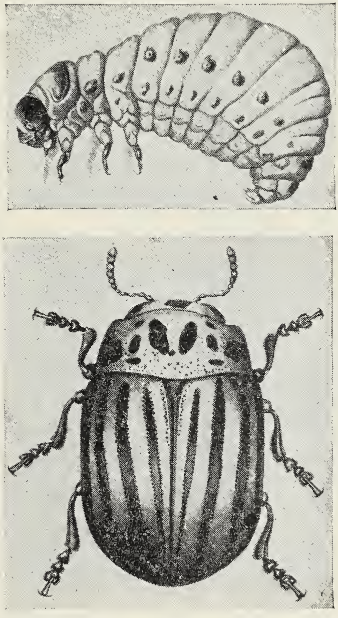


FIG. 148. Above, larva and below, adult of the Colorado potato beetle. Both are much enlarged. (Photos from Dominion Department of Agriculture, Ottawa)

Control is accomplished by the use of (*a*) arsenical sprays, such as 2 pounds of lead arsenate and 3 pounds of hydrated lime in 40 gallons of water, or 1 pound 50 per cent DDT wettable spray powder in 40 gallons of Bordeaux mixture (4-2-40) or water (garden quantity, $1\frac{1}{2}$ level tablespoonfuls to 1 gallon of water); (*b*) dusts, such as $\frac{2}{3}$ per cent DDT and a fungicide, or 1 pound of lead arsenate and 3 pounds of hydrated lime, or 1 part of lead or calcium arsenate and 10

FIG. 149. Adult of the Colorado potato beetle and the injury it causes. (Photo from Dominion Department of Agriculture, Ottawa)

parts common flour. Repeated treatments are usually necessary.

The cutworm. The cutworm is one of the most destructive insects with which the farmers of Western Canada have to contend. Two species are especially important, the red-backed and the pale western.

The adults in each case are grayish-brown, medium-sized, night-flying moths, commonly called moth millers. The moths lay their tiny, pale-coloured eggs in soft, dusty soil during the summer and early fall months. The eggs do not hatch until the middle of the following April. The larvae are soft bodied, cylindrical, soil-coloured caterpillars, about an inch and a half long. The red-backed cutworm is dark gray in colour, with two broad bands of dull red along its back. The pale western is a pale slate gray with a yellowish head, on the front of which are two distinct, short black marks. By the middle of June, the larvae are full grown and pass into the pupa stage. Small, oval, earthen cells are formed, in which the cutworm remains until about August 1st, when the adult moth emerges and at once begins to lay numerous eggs.

Exercise

Look for the pupa cases when ploughing or working in the garden in the early summer; they are readily discovered. They are from a half to three-quarters of an inch in length and light brown.

If you find one or two, leave them in a moderately warm place, and watch them carefully. It is best to place them in a covered box, so that the moth cannot escape until you have had an opportunity to see it.

Fig. 150. Pale western cutworm moth (enlarged). (Photo from Dr. R. D. Bird)

Cutworms attack practically all crops of field and garden. During the day, the larvae remain underground, coming to the surface at night to feed. They move more freely in dry, loose soil, and do most damage in dry seasons. Usually, they completely cut the plant off at or just below the surface of the ground, but frequently the tops are also eaten. The critical period for cereal crops is just before the plants begin to stool out. Some cutworms feed upon the leaves and fruits of plants.

Control measures. (*a*) *Pale western cutworm.*—(1) The larvae of this species feed above ground, cutting notches and holes in leaves of young plants, for ten days only. After this, their activities are entirely below the surface. Thus they cannot be controlled by poison baits. (2) Infestations may be prevented, however, by cultivating the soil as necessary up to August 1st, after which cultivation should cease until September 15th to allow the surface of the soil to become crusted. This soil condition prevents the moths from laying eggs. (3) In stubble fields or summerfallow where an outbreak is expected, young cutworms may be killed by starvation as follows: When weed seedlings are from one to two inches high, all green growth should be destroyed by cultivation. The crop may then be sewn from seven to ten days after weed growth has been completely removed. Cultivation must be accurately timed—between the appearance of weed seedlings and the development of a thick green cover of weeds. (4) If a first crop is destroyed, the field

Fig. 151. Above, red-backed cutworm; below, pale western cutworm.

FIG. 152. The destruction caused by the cutworm, and a cutworm curled up when inactive in the soil during the day or when disturbed. (Drawing from Dominion Department of Agriculture, Ottawa)

may usually be safely reseeded after June 15th to 20th, when the cutworms will have ceased feeding.

(b) *Red-backed cutworm.*—(1) The red-backed cutworms feed at the surface of the soil at night. Poison bait is effective in fields of sweet clover, flax, sunflowers, and corn, in gardens, and in grain crops. The bait is prepared as follows: 100 pounds of bran, 1 gallon of molasses, 4 pounds of white arsenic or 2 pounds of Paris green, and from 7 to 8 gallons of water. The bran and the poison are thoroughly mixed dry, and the molasses is stirred into the water, after which the dry ingredients are added to the liquid. The above mixture should cover five acres. For small areas, 1 quart of bran, 1 tablespoon of molasses, 1 teaspoon of Paris green, with sufficient water to moisten, makes a bait of correct proportions. The bait should be spread thinly on warm, calm evenings. In gardens it may be placed along the rows or around plants of special value, or broadcast generally (the day before seeding or transplanting in Eastern Canada, after seeding but before plants are up on the prairies). (2) If a first crop is destroyed, reseeding is safe within two weeks if cutworms in the soil are one inch long, or within one week if they measure one and three-eighths inches. The new crop should be protected by bait. (3) A tin or paper cylinder placed around young plants of value, so that it extends

three inches below and three inches above the surface of the ground, will afford effective protection. (4) It is essential to destroy all weeds on the summerfallow before August 1st, so that during the egg-laying period no cultivation will be required and the soil may remain crusted. (5) Packing after seeding forces the cutworms to the surface and thus checks the insects.

Grasshoppers. All grasshoppers are not harmful insects, but we are concerned here only with the kinds that damage our crops. All harmful grasshoppers lay their eggs in the fall of the year. One kind lays its eggs in grassy fields and pastures and along roadsides; others lay theirs in bare soil in stubble fields, ditches, and pastures. The young hoppers, which hatch in early May and June, are about an eighth of an inch long and are wingless. The mature winged forms appear about mid-July. (See pages 207-208.)

Methods of control. 1. Poisoned bait may be applied promptly as soon as the insects appear. A common bait is 50 gallons of saw-

Packard grasshopper

Lesser migratory grasshopper

Roadside grasshopper

Two-striped grasshopper

Red-legged grasshopper

Fig. 153. Some of the grasshoppers which cause great damage to our crops. (Photos from Dominion Department of Agriculture, Ottawa)

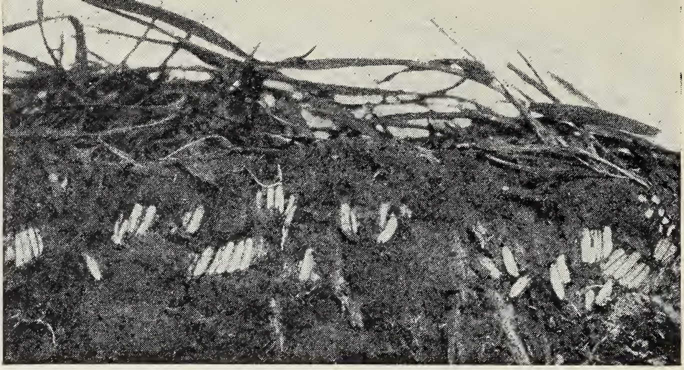


FIG. 154. Roadside grasshopper egg pods in sod. (Photo from Dr. R. D. Bird)

dust and 3 gallons of flour or finely ground mill feed thoroughly mixed and moistened with water into which has been thoroughly stirred $\frac{1}{2}$ pint of aldrin or chlordane. A convenient garden mixture is 2 tablespoonfuls of 40% chlordane, 1 quart of water, and 1 gallon of bran. Bait should be free from lumps. To ensure success, it is important (*a*) to spread the bait thinly (5 gallons of bait per acre), (*b*) to spread it where the grasshoppers are numerous, (*c*) to spread it in a moist condition, (*d*) to spread it on mornings that promise warm clear days when the grasshoppers are feeding, and (*e*) to repeat the operation as often as necessary.

2. The four chemicals now used (1951) for grasshopper control (aldrin, chlordane, toxaphene, and dieldrin) are employed in the preparation of sprays and dusts as well as baits. Sprays and dusts are applied directly to plants on which the grasshoppers are feeding on warm days when the soil surface is hot.

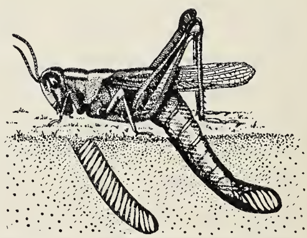


FIG. 155. A grasshopper laying eggs.

In baits, these chemicals give quicker and generally more effective kills than sodium arsenate and Paris green formerly used. Although less dangerous, they also must be handled carefully.

3. A combination of shallow tillage and poison has proved to be very effective in grasshopper control operations. Early tillage destroys needed food before young grasshoppers hatch.

4. Clean summerfallowing is essential. Grasshoppers do not lay eggs in summerfallows that are not weedy. When grasshoppers are numerous, clean summerfallow is the only safe land to sow. The summerfallow should be cultivated before June 1, leaving a black guard strip, from two to three rods wide, around the field. Then the balance should be worked in sections, leaving trap strips of weeds, or strips seeded to grain in the centre of each section. The grasshoppers gather in the strips which should be baited, or the strips may be sprayed. Poisoning should be repeated every few days as needed. When strip farming is practised, the guard strip around each summerfallow strip should be two rods wide.

5. The stubbling in of a crop on poorly prepared soil should be avoided.

6. Crops which are sown early are able, on account of their more advanced growth, to withstand grasshopper attacks better than later crops.

7. Grasshoppers infesting roadsides should be controlled by using poison bait, sprays, or dusts at the proper time.

8. Special efforts to control grasshoppers effectively are necessary when strip farming is practised.

9. Community co-operation is essential to combat successfully serious outbreaks of grasshopper pests.

NOTE.—Watch for annual government insect forecast maps and accompanying informational posters. These contain useful, up-to-date suggestions and advice. Obtain copies for your school.

Wireworms. Wireworms cause serious and widespread damage to field crops, especially wheat, potatoes, corn, and sugar beets, and to most garden crops. They become active early in the spring. In grain fields, their presence is revealed by a patchy, thin condition of the crop. Wireworms attack the seed as soon as it is sown, usually boring into the germ. Later, the growing centres of young stems are entered and killed. Cutworm damage and root-rot injury are not to be confused with the work of wireworms. Cutworms cut off the stems of plants, and root-rots cause

the death of the outer leaves first; but wireworms do not cut off the stems, and they attack the central shoots of the plants first. Wireworms are difficult to locate in the soil except immediately after the first damage is noticed.

The adults of the wireworms are click beetles, so called because, when placed on their backs, they spring into the air with a sharp, distinct click. The beetles are slow moving, dark brown or shiny black insects, not quite half an inch long. In the spring, they appear above the surface of the soil for a few weeks; then they burrow into the soil, where the famales lay their minute white eggs (during May and June). In a few days, the eggs hatch. The larvae, which are the wireworms, are hard bodied, shiny and yellow or orange in colour, and when full grown are about three-quarters of an inch long. The wireworms (or larvae) live in the soil for several years (five, on the average), after which they change to pupae. The pupa stage is passed in small earthen cells from one to two inches below the surface of the soil. The pupae soon change to adult beetles, which remain underground until the following spring.

Fig. 156. A wheat wireworm feeding upon the roots of a wheat plant; and the adult, which is a click beetle. (Drawing from Dominion Department of Agriculture, Ottawa)

Means of control. Strong, healthy plants, capable of making rapid growth, are essential in waging a battle against wireworms. Such plants have a prospect of resisting or outgrowing wireworm attacks. The farmer or the gardener whose crops are in danger should practise methods that will ensure the rapid development of his growing plants. Such methods require:

1. A well prepared and clean seed-bed.
2. Early seeding, as soon as conditions are favourable.
3. Shallow seeding.
4. The use of phosphate fertilizers to hurry plants past the danger or through the attack with less damage.
5. A firm seed-bed and the use of seeding implements that do not loosen the soil excessively. A press drill has advantages.
6. The use of copper carbonate or a mercuric dust to treat wheat for smut, as the dust ensures stronger germination.
7. The sowing of oats or barley in place of wheat when heavy infestations of the wireworm pest occur. Oats are more resistant than either barley or wheat. Clover, alfalfa, grasses, and buckwheat also are usually less likely to be damaged by wireworms.

Encouraging rapid crop growth, however, is not enough to safeguard crops against damage by wireworms; it is necessary also to attack the insect itself by:

1. Keeping the summerfallow entirely free of weeds from June 15th to the end of July. Newly hatched wireworms that may be in the soil are thus deprived of a food supply.
2. Practising shallow cultivation during the latter part of July to destroy pupae (this may facilitate egg-laying activities of cutworm moths). Only such cultivation as is necessary to destroy weeds, however, should be undertaken.
3. In gardens, using baits, such as slices of potatoes or balls of dough (about size of walnuts). The baits are set near the surface of the soil some time before the crop is planted. Each bait is examined daily and, after the wireworms in it have been removed, is replaced or renewed. A period of three or four weeks is necessary to obtain effective results. In Eastern Canada, the baits are set out ten feet apart; but on the prairies a closer grouping is recommended.

Several promising chemical soil and seed treatments are being developed; of these, benzene hexachloride is the most effective.

The wheat stem sawfly. This insect has in recent years caused a great deal of damage to the wheat crops of Western Canada.

The adult is a "wasp-like" insect, black in colour, with three yellow bands on the abdomen and yellow legs. It is about a third of an inch long. Look for it any time from June 1st to the middle of July. It is easily discovered, resting head downward upon the stems of grain or grasses. From the middle of June to the end of the first week in July, the females are busy laying tiny white eggs on the stems of grains and grasses, just above the top joint. These eggs hatch in from three to four days. Immediately the larvae, which are about half an inch long and white, begin to work their way down through the stems, eating the inner parts as they go. About August 1st they reach the roots and cut the stems off at the surface of the ground. The stubs of the stems are then sealed with a sawdust plug, the larvae remaining there during the winter. The following spring the larvae change to pupae, and later emerge as adults.

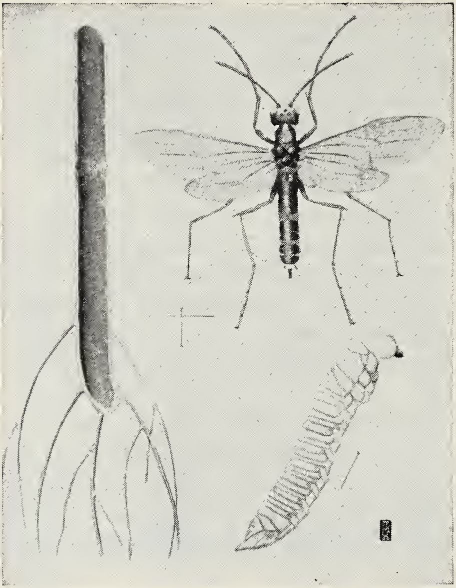


FIG. 157. The wheat stem sawfly; left, base of a wheat plant, showing how the larva has tunnelled through the lower joint and severed the base near the ground; top right, adult; lower right, larva. (Photo from Dominion Department of Agriculture, Ottawa)

The presence of the larvae is at first detected by a blackening of the stems near the joints. If a stem is examined, the tunnels made by the larvae as they travel downward, and the dust re-

maining, are readily discovered. During the latter part of July, after a wind or rain storm, many of the stems will be broken. Just before cutting time, the plants will be severed at the surface of the ground.

Control measures. 1. Wheat should be sown only in uninfested fields (summerfallow or following flax, oats, or some other resistant crop). The production of successive crops of susceptible wheat or rye should not be attempted when fields have become infested with sawflies.

2. Protect the main crop by planting a trap strip around it as follows: (*a*) The trap crop may consist of a strip of wheat or brome grass about a rod wide. (*b*) A barrier strip of vegetation-free soil about a rod wide should be established between the trap strip and the crop to be protected. The trap strip receives the bulk of the eggs laid by the adults. When wheat is used as the trap, good seed should be used and sown about ten days before the main crop. Wheat traps should be cut low about July 10th to 15th, before the larvae have descended to the base of the stems. Brome traps should also be cut early. Where it grows satisfactorily, brome grass may be used along roadways and fence rows as a permanent trap crop. It has been demonstrated that the most effective use of permanent trap strips depends upon community effort. A combination of permanent brome trap and annual wheat traps is effective.

3. Resistant crops such as Rescue or Durum wheat, oats, flax, sweet clover, and barley may be sown on wheat or rye stubble as a means of preventing serious sawfly damage.

4. Shallow cultivation during the first part of June or immediately after harvest to leave infested stubs on the surface or ploughing deeply with a moldboard plough to bury pupae are effective control measures.

5. When sawflies are present, wheat should be cut slightly on the green side as a means of saving it.

The effective control of the sawfly is particularly important when strip farming is practised.

Fig. 158. An illustration of the damage caused by corn borers. (Photo from Canadian Industries Limited)

The European corn borer. This injurious insect occurs in Eastern Canada. It attacks the stalks and cobs of corn, causing serious damage by tunnelling through the plants and thus breaking them.

The adults are yellowish-brown moths, which are to be seen about the end of June. The eggs are laid in clusters on the underside of the leaves. Soon after hatching, the larvae enter the corn plants and begin tunnelling. When full grown, the larva is about an inch in length, white or brownish in colour, and has a dark head and numerous dark spots on its body. The larva passes the winter in corn refuse in the fields.

Control measures. To prevent damage by the corn borer, all corn crop remnants should be completely disposed of by feeding to live stock, ploughing under, or burning before the following first of June or earlier. Spray with 1-1½ pounds of 50 per cent DDT wettable spray powder or 2 pounds of derris plus a spreader in 40 gallons of water, or dust with 3 per cent DDT or derris. Four applications should be made at five day intervals when the eggs are laid. Co-operative community effort is essential, as the moths fly considerable distances.

The codling moth. The codling moth is the most destructive apple insect pest. Every year it causes serious damage in all the chief apple-growing districts of Canada. Pears are also extensively attacked by it. The larvae of the insect bore into the apples and feed upon the pulp and the seeds. Infested apples fall from the trees or become unmarketable as a result of the

tunnelling of the insect and the accumulation of castings at the calyx end of the fruit.

Full grown larvae are about three-quarters of an inch long. They are pinkish-white or cream-coloured, and have black, shiny heads when young, and glossy, brown heads when mature. Other characteristic markings are a dark spot on the collar, dark-coloured projections scattered over the body, and a dark area just above the tip of the abdomen. As soon as they hatch from the eggs, the larvae enter the apples through the calyx end or through wounds. They spend twenty-five or twenty-six days as larvae; then they spin cocoons, in which they pass the winter. The cocoons are located under loose bark or in other protected places. In May, usually, the insect pupates. The adults begin to emerge soon after the apple blossoms have fallen and continue to emerge up to the middle of July. Some of the larvae may pupate during the summer—in the milder parts of Ontario, for example—to form a second brood, which attacks apples from early August to September. The adult is a small moth, with a wing spread of three-quarters of an inch. The front wings are dark gray, and the hind

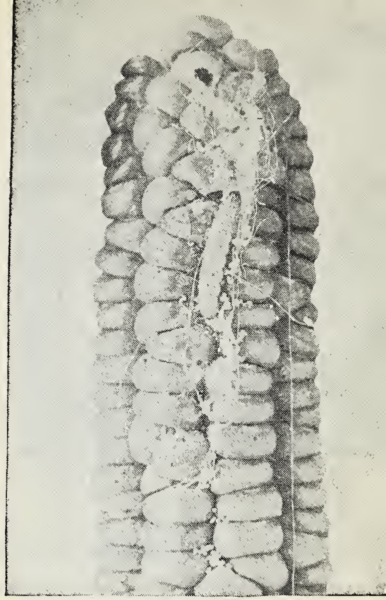


Fig. 159. Caterpillar of the European corn borer attacking an ear of corn. (Photo from Dominion Department of Agriculture, Ottawa)

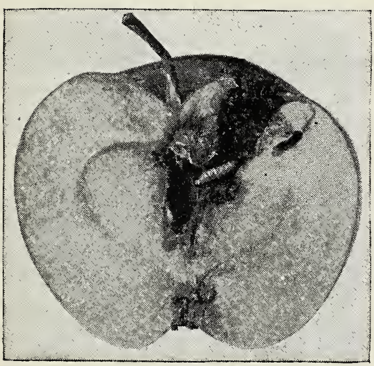


Fig. 160. Codling moth caterpillar and its destructive operations in an apple. (Photo from Dominion Department of Agriculture, Ottawa)

FIG. 161. Blister beetles on caragana. (Photo from Dr. R. D. Bird)

wings light brown. Near the tip of each front wing is a well marked, golden-brown patch. The eggs are laid chiefly on the leaves of the apple trees. They hatch in from nine to ten days.

Control measures. Control of the codling moth is accomplished by thorough spraying of the trees. Following the earlier spraying of trees for scab and other insects, the trees should be sprayed when all the petals are falling, using $3\frac{3}{4}$ pounds of lead arsenate, 4 pounds hydrated lime, 6-8 pounds of microfine sulphur in 100 gallons of water. Liquid lime sulphur, at the rate of $1\frac{1}{2}$ gallons, may be substituted for the microfine sulphur in the formula just given, but at this time it often results in severe foliage injury and consequent poor set of fruit. Fine later sprayings are recommended at intervals of ten to fourteen days, using lead arsenate or DDT in various fungicides, oil emulsions, or water. Several of the provinces, Ontario and British Columbia for example, publish spray calendars which students who wish further details may consult.

Insects attacking shade trees and shrubs. Insects, such as leaf rollers, sawflies, scale insects, gall-forming and other plant lice, leaf beetles, canker worms, tent caterpillars, miners and borers, fall webworms, and others, often seriously damage the vitality and appearance of valuable ornamental and shade trees and shrubs. Various insecticides may be used to control these insects.

FIG. 162. Winged, spring, migrant aphid (very greatly enlarged). See Figure 145. (Photo from Dominion Department of Agriculture, Ottawa)

Exercise

When swellings or deformations known as galls, curled, skeletonized, blistered, withered, or otherwise damaged leaves, swollen or scale covered twigs, scarred bark, foliage covered with sticky honey-dew of aphids, or other indications of insect presence and damage are discovered, the student will find it profitable to learn about more of the insects concerned. When trees are valuable, it pays to take steps to protect them from insect injury.

Potential pests. There are a number of insects which at present feed only on wild plants closely related to cultivated crops. There are other insects which are serious pests in other countries but which have not as yet appeared in Canada. It is possible that some factor may cause certain of these insects to become serious pests in our garden or field crops. To assist in preventing the establishment of such insects, farmers and gardeners should forward to the proper authorities specimens of and information about insects which they find occurring in numbers and damaging crops.

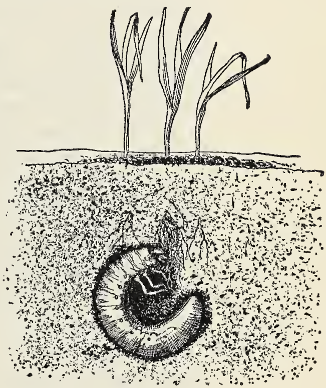


FIG. 163. White grub feeding on the roots of grasses. (Drawing from Dominion Department of Agriculture, Ottawa)

When studying this chapter, the student should give his attention chiefly to the insects most common in his locality and should avoid emphasis on details of formulae which are included primarily for reference.

The objectives should be an understanding of the importance of the problems involved and an appreciation of the knowledge required on the part of the farmer and gardener to cope with them.

Exercises

1. As each insect is studied, a series of drawings should be made to illustrate its life history and distinguishing characteristics. It is important to show clearly the attachment of the appendages (legs, wings, etc.).

2. Collect pupa cases that you may find. Dissect a few. In some you should find the larva; in others, more mature, the adult almost ready to emerge. Put several away, still attached as you found them, if possible, and watch for the adult. Do not be too anxious for results. Some adults may not emerge for months.

3. Caterpillars may be collected and placed in glass jars or boxes covered with wire netting containing moist earth or sod. Supply them with the same kind of leaves as they were feeding upon when you found them. Watch for the cocoon making preparations.

4. Look for grasshopper eggs early in the spring. Put some in a bottle, loosely corked, and place it in a warm, sunny location. In a short time the eggs will hatch out. Observe the size, the colour, and the characteristics of the nymphs.

CONTROL PRINCIPLES:—When planning controls several factors must be considered: effectiveness and cost vs. resulting saving, possible methods of application, equipment available, in some cases the effect upon the soil, etc.

5. Watch for the nymphs in field and garden. In the spring and early summer they are quite easily discovered.

6. If other insects are more injurious in your district, they should be studied before those mentioned above.

7. Outline methods employed to control insect pests. Mention cultural methods, insecticides, beneficial parasitic insects, co-operative efforts. Name several insects that may be destroyed by each method. Make a separate list of insecticides or poisons, and give examples of the insects against which each insecticide is effective. Are the insecticides which you mention stomach or contact poisons?

NOTE.—The Department of Biology, University of Saskatchewan, Saskatoon, will identify insects (as well as other animals and plants) for teachers and others. When possible, specimens of the insects should be forwarded with the request for identification. Soil insects should be placed in soil in a tight tin. The Dominion Entomological Laboratory, Saskatoon, will also identify insect pests.

Projects

1. Make a collection of fifty or more species of insects. Write for *Directions for Collecting and Preserving Insects*, Publication 520, Department of Agriculture, Ottawa.

2. Prepare specimens of the various stages in the life history of a number of insects; for example, the potato beetle. The adults, larvae, and eggs of this pest are easily found on the potato plants. Look in the soil for the pupae; or, in the fall, place several larvae in a box or glass jar containing moist earth, and feed them with fresh potato leaves until they pupate.

3. Students who are caring for gardens should be familiar, at least, with the characteristics, the nature of the damage, and the control of the following insects, as well as those mentioned in the foregoing paragraphs; the various species of flea beetles, which are quite small and eat holes in the leaves of turnips, radishes, potatoes, tomatoes, cucumbers, cabbages, beans, squashes, and a number of flowering plants; the soft, slender bodied blister beetles, which feed on potatoes, beans, beets, carrots, tomatoes, and flowering plants; the root maggots, which destroy the roots of cabbages, cauliflower, radishes, turnips, grasses, grains, and onions—the adults are flies; the white grubs, which are the larvae of the common May beetles or June bugs and attack the roots of garden and field crops; the slender, hard, shiny, brownish wireworms, which are the larvae of click beetles, and damage onions, potatoes, grasses, and cereals; the currant sawfly, and others.

Bulletins may be selected from the *Lists of Publications* of the Dominion and the various provincial Departments of Agriculture.

Earthworms. Earthworms are very important because of the good work which they do in pulverizing, aerating, and stirring up the soil, which is their chief food. They take the soil into their bodies, absorb the digestible parts, and excrete the remaining and larger portions. This process has a pulverizing effect upon the soil. The burrows of the earthworms make openings for the entrance of water and air into the soil, and their digging activities constantly bring large quantities of new soil to the surface of the ground.

The value of birds in agriculture. Insects are responsible for tremendous losses. In Canada, alone, they damage trees and crops to the extent of $200,000,000 annually. It is well to note also that some insects cause serious loss in the way of animals or animal products. A good example is the warble fly which has caused tremendous losses in Eastern Canada in particular. The loss

takes the form of less milk from cows, less flesh on beef cattle, and seriously damaged cattle hides. Birds are the natural enemies of injurious insects. Birds also destroy weed seeds; many of our summer birds and the forty-three species of our winter birds live principally upon weed seeds. It would seem to be a sound "dollar and cents" proposition to encourage, therefore, by every means possible, an increase in the number of birds.

WHAT SOME OF THE BIRDS EAT*

Bluebird—68 per cent insects; grasshoppers, beetles, caterpillars.

Kingbird—85 per cent insects; flies, mosquitoes, locusts, blister beetles, crickets, cutworm moths.

Meadowlark—ground beetles, caterpillars, cutworms, army worms, grasshoppers, weevils, 24 per cent weed seeds.

House Wren—grasshoppers, beetles, bugs, spiders, cutworms, wood ticks, plant lice.

Chickadee—70 per cent insects; moths, caterpillars, beetles, ants, wasps, bugs, flies, spiders, and poison ivy berries and weed seeds.

Franklin's Gull—(the gull that follows the ploughman)—cutworms, dragonflies, beetles, ants, grasshoppers, wireworms, click beetles, May beetles, weevils.

Robin—58 per cent wild berries, 42 per cent worms and insects.

Song Sparrow and Chipping Sparrow—noxious weed seeds, beetles, weevils, ants, wasps, bugs, caterpillars, plant lice.

Hawks—with the exception of Sharp-shinned, Cooper's, Pigeon, and Goshawk, do not maliciously attack poultry but destroy insects, mice, and gophers.

Owls—The Great-Horned Owl is the only one that destroys poultry.

Exercise

What birds are harmful? What is the nature of the damage? How can harmful birds be destroyed? Are any birds, usually considered harmful, beneficial in some respects.

Gophers and their control. Four types of gopher are found on the Canadian prairies; the common gray Richardson gopher, the striped gopher, the mole or pocket gopher, and the squirrel tail or scrub gopher. The Richardson gopher is the most common and causes very serious damage. The pocket gopher is also a bad pest in some districts.

*From Extension Bulletin No. 52, Manitoba, by V. W. Jackson.

Poisoning seems to be the most effective method of destroying the Richardson gopher. The following mixture is effective: 1 ounce of strychnine sulphate dissolved in 2 quarts of hot water. Stir until all the strychnine is dissolved, boiling if necessary. Add 1 pound of sugar or 1 pint of molasses, and 1 teaspoonful of oil and anise. Pour the hot solution over half a bushel of wheat, and, if necessary, add enough hot water just to cover all the wheat. Let the grain stand in the solution for twenty-four hours. If any of the solution is then unabsorbed, add a handful of shorts, and stir the whole mixture well.

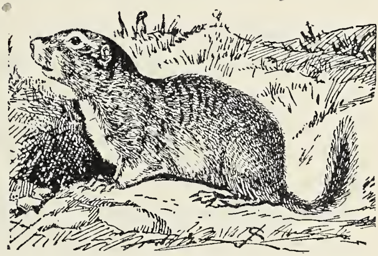


FIG. 164. The flickertail or Richardson gopher, the most common and most destructive gopher of the prairies. (Dawing from Biology Department, Manitoba Agricultural College)

The poison mixture should be used early in the spring. Why? A tablespoonful is sufficient in each hole, and if it is placed deep in the hole, fewer birds will be poisoned. Other poison preparations are also useful. Sodium arsenate is the poison agent in one mixture. Several commercial gopher poisons are sold ready for use. (Note.—Strychnine and arsenic are both deadly to humans.) The pocket gopher apparently is best controlled by trapping or by fumigation with carbon-bisulphide. See also *Guide to Farm Practice in Saskatchewan.*

CHAPTER 11

TYPES AND BREEDS OF FARM ANIMALS

A remarkably large number of the familiar breeds of horses, cattle, sheep, swine, and poultry were produced by the early live stock breeders of England and Scotland. In addition to these there are breeds, developed in other parts of the world such as the Corriedale sheep of New Zealand, the Brown Swiss cattle of Switzerland, etc., that are not raised in Western Canada. These breeds have been developed to meet the particular requirements of the country in which they are found, and in most cases are not suited to our conditions. Only the breeds most commonly raised in Canada are discussed in the following pages. Any of them may be considered as suitable in general for our purposes, except where their specific value is definitely outlined.

Type and breed defined. A *type* is a class of animals possessing general characteristics that make them especially suitable for a certain purpose; for example, the beef type of cattle or the draft horse. A *breed* is a class of animals which is descended from the same ancestors and has similar general characteristics; for instance, the Percherons, Shorthorns, etc.

Classification of horses. Horses are classified according to type and size, and their suitability for various kinds of work, as follows:

Draft Horses	*Heavy Draft*—1800 pounds and over *Light Draft*—1600 to 1800 pounds *Agricultural*—1400 to 1600 pounds *Farm Chunk*—1200 to 1500 pounds *General Purpose*—1200 to 1500 pounds
Light Horses	*Heavy Harness or Carriage*—from 1100 to 1500 pounds—a fairly large driving horse *Light Harness or Roadster*—from 1000 to 1250 pounds—a lighter, faster horse for driving and racing

Light Horses —*Continued*	*Saddle Horses*—polo ponies, 850 to 1000 pounds—cavalry horses, 950 to 1100 pounds—hunters, 1000 to 1250 pounds—riding horses for speed and endurance

The draft horse. The draft horse has been developed for moving heavy loads. Horses of this type are large, heavy, deep, thick, lowset, compact, and muscular. Explain each of these terms. The head of the draft horse should be broad between the eyes and

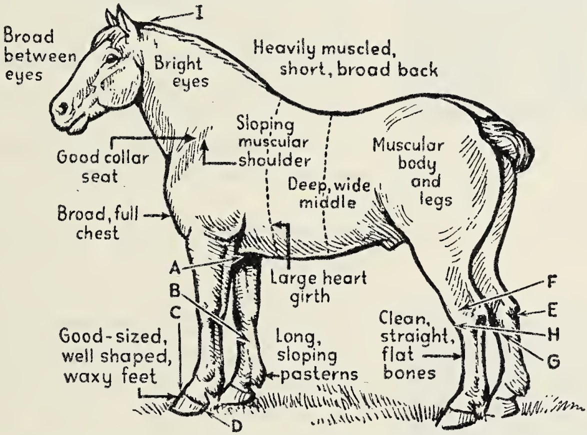


FIG. 165. The draft horse has a deep, broad, muscular body; well formed feet, and legs; and travels with a long, easy stride. Letters A-F show location of unsoundness.

of medium size. A large, bright, prominent eye indicates intelligence and an energetic disposition. The neck should be full and muscular and well blended into the shoulder. The desirable shoulder is sloping and well muscled, with a good collar seat. Why is each of these characteristics essential? Strength of constitution is indicated by a broad, deep chest and a large heart girth. The back should be short, broad, and heavily muscled. Long, well sprung ribs, forming a deep, wide middle, are essential. The hind quarters should be wide and muscular. Also, the horse should have feet and legs that will not readily become unsound. The forearm and gaskin should be well muscled. The bones of the

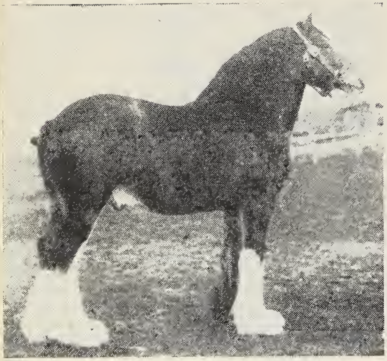


FIG. 166. An excellent Clydesdale stallion, showing power, quality, and beautiful balance. (Photo from Clydesdale Horse Association of Canada)

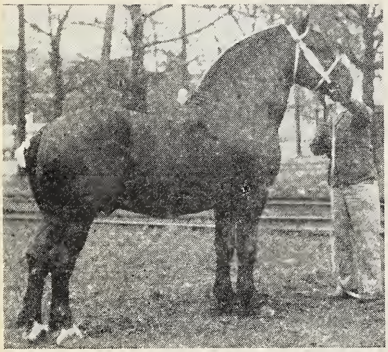


FIG. 167. This Percheron stallion is a splendid representative of his breed; he shows substance, quality, and great strength. (Photo from Saskatchewan Live Stock Branch)

legs should be broad, flat, and clean—that is, with no softness or puffiness, especially at the joints. Long, sloping pasterns improve the action of the horse and the wearing qualities of his feet and legs. The feet should be broad, deep walled, and waxy. The horse should have good action; that is, he should travel straight with a long, easy stride, lifting his feet up and down squarely, and flexing the knees and hocks well. Quality is also essential and is indicated by a clean-cut, alert appearance, silkiness of coat, and fineness of conformation of bone.

Breeds of draft horses. The Clydesdales originated in the Clyde Valley, Scotland. In colour they are usually bay or dark brown, with white feet and faces. The legs are covered with long hair called *feathering*. The "Clydes" excel in action and in quality of bone.

The Percherons originated in the province of La Perche, France. Blacks and grays are the most common. They are stoutly built, with wide, deep bodies. Their legs are clean, with little or no feathering. The Percherons are usually quite docile and are popular as one of the best all round breeds of the draft type.

The Belgians were first bred in Belgium. In colour they are chestnut, bay, brown, or roan. They are the most compact of draft horses; no other breed shows such development of body with

respect to width and depth, especially in the chest. As a rule they are lower set and blockier than the Percherons. They are one of the most useful breeds of draft horses.

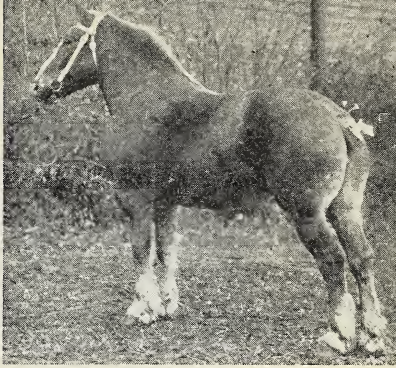


FIG. 168. A Belgian mare. Note the depth and width of her powerful, compact body. (Photo from Saskatchewan Live Stock Branch)

Heavy harness horses. The Hackneys were developed in Great Britain as large driving or coach horses. They are high spirited, medium in size, and rather powerful in build. Their bodies are smooth and symmetrical. They are extreme in action, lifting their feet very high, with a fine bold stride. Chestnuts are the most popular, although the Hackney may be bay, brown, or black.

Light harness horses. The American Trotters and Pacers or the American Standard Breds have been developed in America essentially as driving horses and racers. They are noted for their speed and endurance. In general, they are slim and muscular, and their bodies are narrow but of great depth. Another breed of light harness horse is the Appaloosa.

Saddle horses. The Thoroughbreds are a breed developed in England for racing under the saddle. They are tall, slim, and high spirited, with exceptional quality of structure and stamina. The Thoroughbreds are the fastest of all horses and are usually bay or brown in colour.

FIG. 169. A Standard Bred Stallion, recognized as representing the best type of his breed. (Photo from Canadian Standard Bred Horse Society)

The three- and five-gaited American saddle horses are popular in the show ring. Palominos or Golden Horses

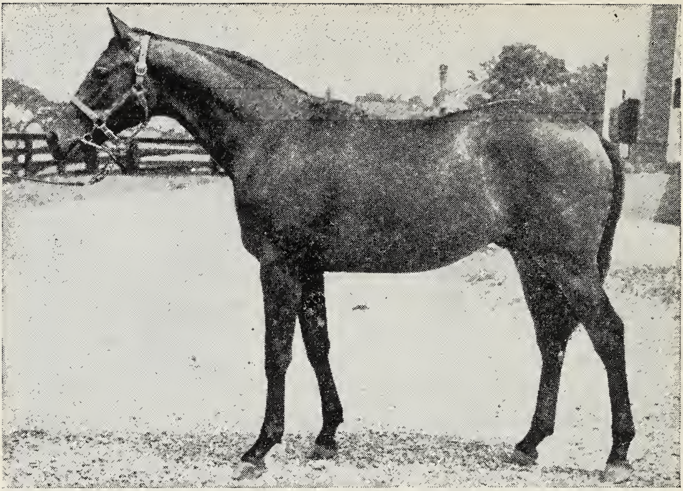


FIG. 170. A Thoroughbred race horse. (Photo from Canadian Thoroughbred Horse Society)

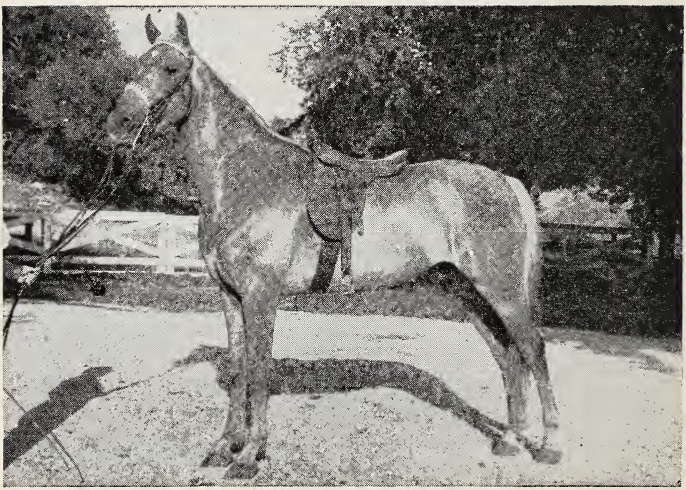


FIG. 171. A five-gaited saddle horse.

have been developed as stock or ranch horses and for parade and pleasure purposes.

The Arabians are the oldest breed of horses and are noted for their courage, quality, symmetry of form, and graceful action. They are the foundation of most of the other breeds of light horses, but as a breed are not important in America.

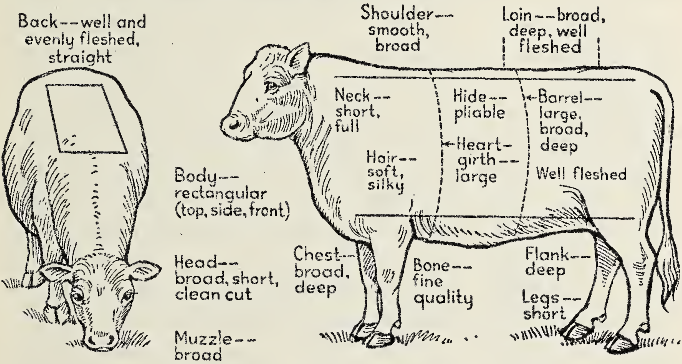


FIG. 172. Good beef cattle are long, broad, deep, low set, and blocky. The back should be straight and parallel to the underline, forming a rectangular-shaped body.

Types of cattle. Cattle are raised chiefly to produce meat and milk. It has been found that the type most suitable for the production of meat will not produce a large quantity of milk. For this reason, two types of cattle have been developed. The dairy type may be regarded solely as machines for the production of milk. They are lean and angular and altogether different from the beef type, which are thick, blocky animals, heavily covered with flesh. There are also dual purpose cattle, which will produce a fair quantity of milk and at the same time possess desirable meat producing qualities.

When cattle are slaughtered, they serve many purposes. Their hides are used for making leather. Buttons are manufactured from the bones and horns. The hoofs are used to produce glue. From the waste parts of the body a fertilizer is produced that is valuable in restoring certain plant foods to the soil. Little there-

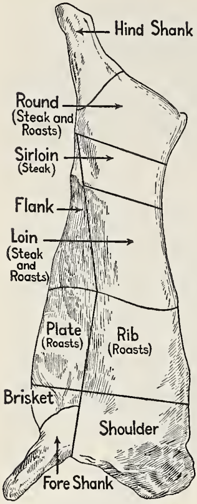


FIG. 173. A side of beef showing the method of cutting up. Officially graded beef is branded —blue brand indicates "good" grade, and red brand "choice" grade.

fore, is wasted. We have learned to depend upon our cattle for a great many useful articles.

The beef type. To produce good beef, cattle must be long, deep, wide, lowset, and blocky. A rectangular conformation is desirable. The back should be strong and straight, and the underline straight and parallel to the topline. A short, wide head with broad muzzle indicates feeding ability. The neck should be short and full, and should blend well into a broad, compact shoulder. An animal with a strong constitution must have a broad, deep chest and a large heart girth. Ability to consume a large quantity of feed is indicated by long, well sprung ribs, forming a deep, wide middle. The loin should be broad and thick. The hind quarters should be fleshed well down to the hock, and should carry the width of the rest of the body well to the rear. In finished animals, the whole body must be covered with a deep, uniform layer of flesh, especially over the back, loin, and hind quarters, as these parts produce the highest priced cuts of meat. The flesh should have a soft, mellow feeling, and the hide should be thin and pliable. The animal should have an appearance of quality as evidenced by fineness of head,

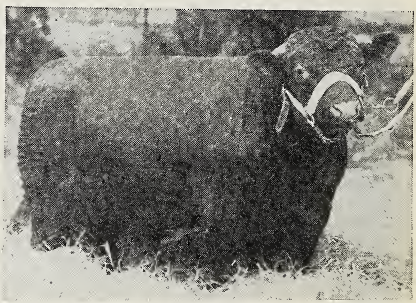


FIG. 174. This Shorthorn bull is a champion and appears to know it. Note the straight topline and deep, wide, smooth body. (Photo from Saskatchewan Live Stock Branch)

Fig. 175. A top ranking group of Herefords showing splendid breed and type characteristics. (Photo from Saskatchewan Live Stock Branch)

bone, hair, and hide. Why are coarse boned beef cattle objectionable?

Breeds of beef cattle. The Shorthorns were developed in Northern England. In colour they are red, white, or roan. They are the largest and one of the best all round breeds, being long, deep, wide, lowset, and well developed in the hind quarters. The Shorthorns are easy to feed. From the beef breed, the Polled Shorthorns have been developed to meet the demand for hornless cattle. There are also Milking Shorthorns.

The Herefords, sometimes called the "White Faces," originated in Herefordshire, England. They are red or wine-coloured, with white on the face, chest, and underline. They are a breed of early maturing qualities and have the ability to rough it in the open during the winter. The Herefords are especially good grazers. There are also Polled Herefords.

The Aberdeen Angus are hornless black cattle. They are supposed to have developed from the wild cattle of north-eastern Scotland. While not as heavy as the Shorthorns or Herefords, they are superior for indoor feeding, being the smoothest and most

Fig. 176. An excellent Aberdeen Angus bull, showing the smoothness and even fleshing of the breed. (Photo from Saskatchewan Live Stock Branch)

evenly fleshed of the beef breeds. The smoothness, early maturity, uniformity, and high dressing percentage of the "Doddies," as they are sometimes called, make them popular for the production of high quality meat, especially baby beef.

The Galloways originated in south-western Scotland. Like the Angus, they are black and hornless, but they are characteristically rougher and covered with long, thick, wavy hair. Their hides are often used in the manufacture of robes. They are noted for their ability to withstand hardship and cold, but are slow maturing and inclined to be small. While not as popular as some other breeds, they are, nevertheless, easy feeders and dress out well.

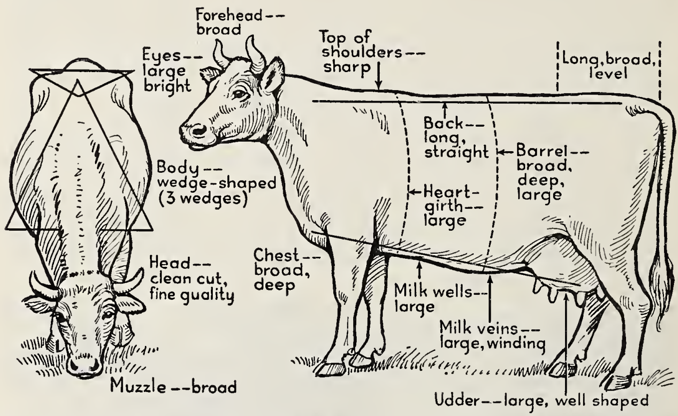


FIG. 177. In sharp contrast to the beef animal, the dairy cow is wedge-shaped, lean and angular.

The dairy type. The type of cow that is bred for heavy milk production differs greatly from the beef type. The dairy cow is spare in flesh, angular, and wedge-shaped. There are three wedges, one from the front, one from the side, and one from the top. The head is longer than that of the beef breeds. A broad forehead, large, prominent eyes, and a broad muzzle are desirable. The neck is longer and thinner, and the shoulders are sharper than

FIG. 178. Not only are these Ayrshire cows of a good type, but all have established very high records of production. Such cows when properly fed and well kept, will produce the greatest profits. (Photo from Canadian Ayrshire Breeders' Association)

FIG. 179. A Holstein-Friesian cow showing the excellent mammary development which is characteristic of this breed of high producers.

those of the beef breeds. Because the production of milk is hard work, the dairy cow must be strong in constitution, as indicated by depth of chest and width between the front legs. The ribs should be long and well sprung, as the cow that produces large quantities of milk must be able to consume large amounts of feed. The best udder is large, well formed, evenly balanced, attached high up behind, and carried well forward under the body. The milk veins, which pass along the under part of the cow's body and carry the blood from the udder to the heart, should be winding and large. A good flow of blood is essential, as the milk is produced from the blood. The milk wells, by which the milk veins enter the body, should be large, and it is better if there are more than one on each side of the body. A good dairy cow must also have a refined, alert appearance, with a clear, bright eye, indicating a highly developed, active nervous system.

The dairy breeds. The Holstein-Friesians are natives of the province of Friesland, Holland. They are black and white in colour, and are the largest of the dairy breeds. Holsteins are hardy, docile, and easily managed, and are the heaviest milk producers, having records as high as 20,000 pounds or more per year, although their milk is not as rich in butterfat as that of some of the other breeds of dairy cattle. They are the most common dairy breed in Canada.

The Ayshires originated in Ayr county, Scotland. They are next in size to the Holsteins and are red and white in colour. The prominent upright horn is one of their distinguishing characteristics. The Ayrshires tend to be less angular and more like the beef type than the other dairy breeds, but are good milk producers.

The Jerseys are a dark or gray-fawn-coloured breed, developed in the Isle of Jersey, one of the Channel Islands. They are the smallest dairy breed, and, while they are not heavy milk producers, their milk is very rich in butterfat. The Jerseys are outstanding in dairy conformation and are essentially butter cows.

The Guernseys were first bred in the Isle of Guernsey, another of the Channel group. They are fawn in colour, with white mark-

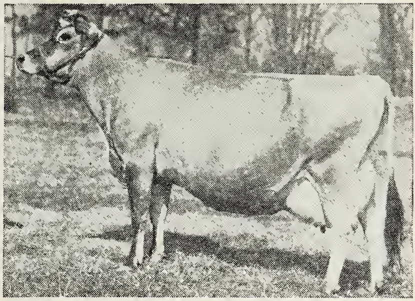


Fig. 180. A 13-year old Jersey cow with nine records totalling 8163 pounds of butterfat. (Photo from Canadian Jersey Cattle Club)

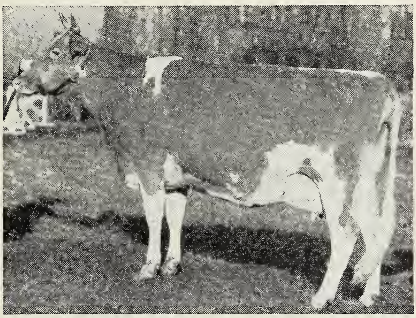


Fig. 181. This Guernsey cow was not milking when the photograph was taken. Nevertheless, she is a champion. (Photo from Canada Guernsey Breeders' Association)

ings. Next in size to the Ayrshire, they are splendid producers of a rich, yellow-coloured milk, which yields a large percentage of butterfat.

The dual purpose type. Dual purpose cattle must possess bodies that conform very closely to the blocky rectangular build of the beef type; at the same time, they must be capable of producing a good supply of milk. Where there is no special desire for marked milk or meat producing ability but where a fair degree of both will suffice, there is certainly a place for the dual purpose cow. Some farmers like to keep a few dual purpose cattle; such cows provide a milk supply and have profitable market value when their milking days are over. The offspring, also, may be raised and sold as beef animals.

The dual purpose breeds. The Milking Shorthorns are similar in colour and other breed characteristics to the beef-type Shorthorns, but in body conformation they are not as beefy, and they possess greater mammary development. They have been developed from the oldest Shorthorn families, and are good milk producers.

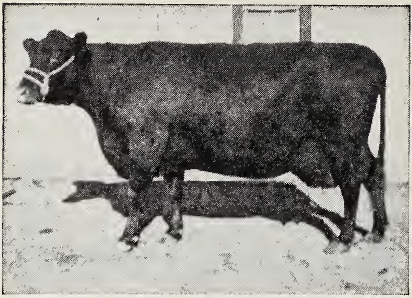


FIG. 182. A Red Poll cow showing a deep, rectangular body. She has a 5-year record averaging 12,891 pounds of milk and 514 pounds of butterfat per year. (Photo from A. D Pocock, Moose Jaw, Saskatchewan)

Red Poll cattle are natives of Eastern England. They are hornless or polled, red in colour, and present a high combination of the rectangular, deep beef conformation, with a good covering of flesh where the high priced cuts of meat are produced, and ability to produce a good quantity of milk.

The classification of sheep. The classification of sheep is based upon the length and the fineness of the wool. There are three types, namely, the fine wool type, the medium wool type, and the long or coarse wool type. The medium breeds are best for mutton production. They have a lowset, rectangular body, similar in general to the beef-type cattle.

The fine wool breeds. These sheep were raised formerly almost entirely for the wool which they produce.

The Merinos originated in Spain, and are the oldest breed of the fine wool type. They have spiral horns, and over the neck and shoulders have heavy folds or wrinkles. The Merinos produce a large quantity of wool of very fine quality.

The Delaine Merinos have been developed in America. They are larger and smoother than the Merinos, and have a better mutton carcass. There are fewer folds on the body, and the wool is somewhat coarser.

The Rambouillets were produced in France from Merino stock to meet the demand for a fine wool sheep with a better mutton conformation. They are the largest of the fine wool breeds, and produce a fair mutton carcass. The females are hornless; the rams are usually horned, the horns being long and spiral. There

Fig. 183. A group of Rambouillet rams.

are folds over the neck, and the fleece is from ten to fifteen pounds in weight. Rambouillets are popular in the range areas of Canada and the United States.

The medium wool breeds of sheep. Sheep are produced in Western Canada for both wool and mutton. The desirable body conformation resembles that of beef cattle. The sheep should be rectangular, wide, deep, and lowset. The back should be strong and wide, and the underline straight and parallel to the topline. Strength of constitution is important, as indicated by width of chest and expanse of heart girth. The best type of head is short and broad, with a strong muzzle, and full, bright eyes. The neck should be short and thick; the shoulders, wide and compact; and the middle, loin, and hind quarters, broad and deep. A smooth thick layer of flesh should cover the body, especially over the shoulder, back, loin, and hind quarters. Why? A bulging leg of mutton is desirable. The fleece should be fine in quality, long, and dense enough to

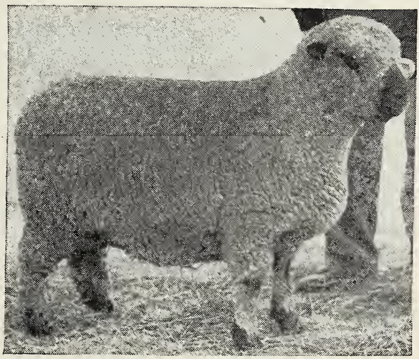


Fig. 184. A Shropshire ewe.

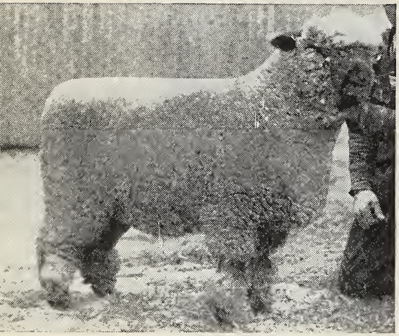


FIG. 185. An Oxford ewe.

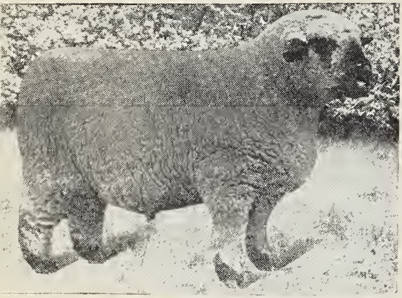


FIG. 186. A Hampshire ram.

offset severe winter conditions. It is important that the wool have a close *crimp* (wave) and a bright lustrous appearance in addition to an abundance of *yolk* (oil). Lambs are marketed at from five to eight months of age, weighing from eighty to ninety pounds. The best sheep for our conditions is an early maturing, blocky, lowset, vigorous, close-woolled type, as best represented by such breeds as those described below.

The Southdowns are a breed of English origin. They are hornless, and their faces and legs are grayish-brown. Their skin is quite pink. They are the smallest of the down breeds, but are a splendid mutton sheep. On account of their compact conformation, smoothness, and early maturing qualities, they may be said to represent in sheep what the Aberdeen Angus stands for in beef cattle. Their fleece is about two and a half inches long and of good quality.

The Shropshires are another hornless breed originating in England. Their faces and legs are dark brown, and both legs and faces are covered with wool. The "Shrops" are of good size. Their wool is about the same length as that of the Southdown. Their lowset, compact form and their hardiness make them a popular breed of sheep in Western Canada.

The Oxfords also were developed in England. They are hornless, and are by far the largest down breed. Their faces, which are dark brown, are not woolled as are the Shropshires. A distinguishing characteristic is a prominent forelock or cap of wool. The fleece is longer, but is a little coarser than that of the Shrop-

FIG. 187. A group of Suffolks.

shires. They are blocky and square, and are, therefore, quite popular.

The Hampshires are also natives of England. They are next in size to and often confused with the Oxfords, but they are easily distinguished by their Roman noses and their very dark feet and legs. They are quick maturing, and a good mutton sheep. The fleece of the Hampshires is the same length as that of the Shropshires.

The Suffolks were first bred in England. They are good mutton sheep, and have black, bare faces and legs. Their fleece is fairly light, weighing from six to nine pounds. They are next in size to the Hampshires.

The long wool breeds. The Leicesters are one of the oldest breeds of sheep. They too originated in England. They are fair sized, very stylish in appearance, but inclined to lack hardiness. The fleece is about six inches long, and open but of good crimp, weighing on the average from eight to nine pounds. Their faces and legs are bare and white. The Leicester is one of the best of the long wool breeds, but is not popular in Western Canada because of its open fleece.

The Karakul sheep. This class of sheep is the source of Persian lamb fur, for which purpose they are raised exclusively. To produce the best quality pelt, the lambs are slaughtered when a few days old. The Karakuls are medium-sized, with drooping ears and broad tails. The wool is long, coarse, and hair-like in appearance and gray to brown in colour. Their feet and legs are black. There are now a few Karakul ranches in Canada. The Karakuls are natives of Bokhara, Asia.

Types of swine. It has been customary to think of breeds of hogs as being divided into two general types—the bacon type, developed to produce bacon, and the lard type, designed to produce fat or lard. The difference in general conformation or form between the lard type and the bacon type of hog is now far less pronounced than formerly. Since the heavy, fat hogs have been discriminated against on the market in both Canada and the United States, breeders of the lard type have stressed leanness rather than lardiness.

The bacon type. Bacon is produced from the back and sides of the body; therefore these parts must be of great length. The desirable type of hog is long of body and of medium depth. The jowls should be light and free from wrinkles; the shoulder, close and smooth; the back, well arched, the sides dropping straight from the back; the underline, straight; and the hams, full but not heavy or wrinkled. Hogs kept for breeding purposes should show strength of constitution and good quality of bone. If you were considering hogs finished for market, would you pay a great deal of attention to strength of constitution? Give a reason for your answer.

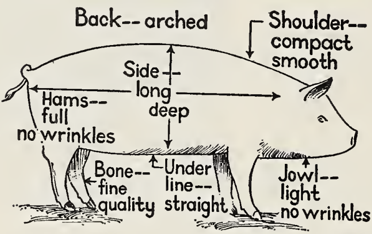


FIG. 188. A finished bacon hog should weigh about two hundred pounds. This diagram illustrates the characteristics of a select bacon hog. Why is length an important good quality?

Market standards. Highest prices are secured for hogs that yield a carcass within the Grade A carcass range of 140 to 170 pounds in weight and twenty-nine inches minimum length. To produce a carcass of this type, hogs should be marketed at a live weight of 190 to 220 pounds. Such a hog produces the best bacon.

Many of the hogs produced in Canada are exported to Great Britain as Wiltshire sides. A Wiltshire side is one-half of a selected

pork carcass, with head, feet, backbone, and shoulder blade removed. (See Figure 189.) Great Britain buys a great deal of Canadian bacon. To produce bacon of the required British standard, a Grade A Wiltshire side must weigh between fifty-five and sixty-five pounds, possess great length, and have the fat and lean well balanced. The present Canadian official method of grading hogs requires that each be tatooed for identification, slaughtered, and hung on the rail for grading.

The advantages of "rail" grading are: The exact carcass weight and the proportion of fat to lean can be readily determined. As a result, the producer who places high quality hogs on the market is more sure of receiving a high price.

Breeds of bacon hogs. The Yorkshires are a white breed, originating in Yorkshire, England. They are by far the most popular breed in Canada at present; in fact they are the only breed that produces carcasses acceptable to the British market.

In 1947, there were 22,363 registered hogs in Canada. Of this number, 19,635, or approximately ninety per cent were "Yorks." The Tamworths (a golden-red English breed) were second with 1180, and the Berkshires (an English breed, black with white face, feet, and tip of tail) were third with 794. The number of commercial hogs would show a similar relationship. The large breeds, such as Hampshire, Chester White, Poland China, and Duroc Jersey do not come into the picture in Canada.

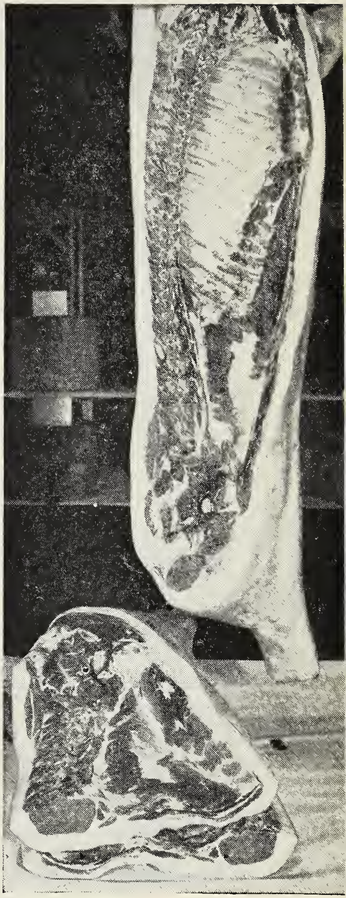


Fig. 189. A high quality Wiltshire side of the type desirable for export trade. (Photo from Dominion Department of Agriculture, Ottawa)

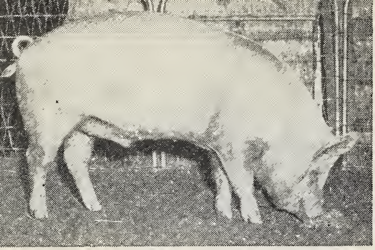


FIG. 190. A Yorkshire hog of good type and quality.

Exercises and Problems

1. Make a summary of the characters of each type of horses, cattle, sheep, and swine, under the following headings: general appearance, head, neck, shoulder, chest and heart girth, middle, hind quarters, quality, finish or condition, and special characters, such as the feet and legs of horses, the mammary development of dairy cows, the wool of sheep, etc.

2. Identify the breeds in your district, and as a project find out the approximate number of each breed.

3. Distinguish between the terms: cattle and beef, calves and veal, sheep and mutton, hogs and pork.

4. Draw charts to represent carcasses of beef, mutton, and pork. Ask a butcher the price of the various cuts. Locate the cuts on your chart, and mark in the prices. What parts of the living animals do the prices of the cuts indicate should be particularly well developed?

5. What advantages do producer and consumer derive from government grading of meat? (See caption of Figure 173.)

6. Which breed or breeds of horses, beef cattle, dairy cattle, sheep, and swine do you consider the most suitable for the average farm in Western Canada? in Eastern Canada? Give reasons.

7. Which breed of dairy cattle would you recommend for straight dairy farming? State reasons for your recommendation.

8. Distinguish between the following types of hog: bacon type, lard type, large type, and small type.

Projects

1. Arrange to visit fairs where live stock are being exhibited. Watch the judges at work.

2. Organize a stock judging team, a baby beef club, or similar activity. Contact your district Agricultural Representative for details of organization and such other suggestions and assistance as the department may be able to offer.

> Teachers are referred to the suggestions regarding objectives and methods, pages v and vii.

CHAPTER 12

THE FEEDING AND CARE OF LIVE STOCK

The problems of animal hygiene and nutrition should be carefully studied by any farmer who wishes to make a success of feeding live stock. Profits depend directly upon the cost and suitability of the feeds used and upon the clean, healthful surroundings in which the stock are kept.

Exercises

To learn something of the constituents of plants, secure the following material: common seeds such as wheat, oats, barley, corn, peas, beans, etc., and the stems and leaves of grasses, grains, corn, or alfalfa.

1. Place a small quantity of finely cut up plant material in a dish. Weigh it accurately. Heat it in an oven at a temperature of 212° Fahrenheit for several hours, cool it, then weigh it again. The loss in weight will indicate the amount of water originally contained in the plant. Conduct this experiment with green plants, dry hay, and mature seeds, and compare the results. The material left when the water has been driven off is called dry matter.

2. Place a small amount of plant material in a crucible. Heat it strongly until combustion is complete. The material that remains is ash or mineral matter.

3. Boil some stems and leaves alternately in a weak acid and a weak alkali (sodium hydroxide). Each time, wash out the dissolved substances. The material remaining is the fibre or *cellulose* which forms the hard, woody skeleton of a plant.

4. Grind up some wheat kernels or other seeds. Place them in a test-tube at a depth of about one inch. Add a third of a test-tube of water. Shake it well. Boil it vigorously for several minutes. Cool it by holding it under a tap or in cold water. Add a few drops of strong nitric acid. Boil it again and cool it. If a yellow colour develops, a substance called protein is indicated. Now add a few drops of ammonium hydroxide, and a deep orange colour further proves the presence of protein.

5. Repeat the foregoing exercise, but add a few drops of iodine solution instead of nitric acid. A deep blue colour indicates starch.

6. Repeat the first part of Exercise 4, this time adding Fehling's solution. When heated, a dull reddish-brown colour indicates the presence of sugar. If there is no reaction from wheat, try peas, sweet corn, or beans. Fehling's solution is produced as follows: dissolve 3.5 grams of copper sulphate in 50 c.c. of water; label this solution A; dissolve 17.5 grams of Rochelle salts in 50 c.c. of a 10 per cent solution of sodium hydroxide; label this solution B. When ready to use, mix solutions A and B in equal proportions. Solutions A and B may be purchased at a drug store.

7. Place a few grains of starch in a dry test-tube; heat it carefully until the starch is completely charred or blackened. Observe the moisture that collects in the cool part of the test-tube. The black substance left in the bottom of the test-tube is carbon, and the water, we know, is composed of hydrogen and oxygen. What is your conclusion as to the composition of starch?

8. Place some crushed sunflower seeds, flax seed, etc., with the shells removed, upon a piece of white paper. Heat it gently over a flame. A grease spot on the paper indicates oil or fat.

The composition of plants. From the foregoing experiments we see that the composition of plants is as follows:

Water—from a very small amount in dry seeds to ninety or ninety-five per cent in potatoes, turnips, etc.

Dry Matter—all materials in the plant except the water.
- (*a*) Fibre—the hard, woody skeleton of the plant.
- (*b*) Ash or mineral matter—calcium (lime), iron, magnesium, etc.
- (*c*) Carbohydrates—these are the starches and the sugars of the plant, and are called carbohydrates because they are composed of carbon, hydrogen, and oxygen, the hydrogen and oxygen being in the same proportion as in water.
- (*d*) Proteins—when nitrogen is combined with carbohydrates, proteins are produced.
- (*e*) Fats—like the carbohydrates, are composed of carbon, hydrogen, and oxygen.

The animal body. From a study of the following table it will be seen that the bodies of animals are composed of the same materials as we have just learned are present in plant bodies.

COMPOSITION OF THE BODIES OF FARM ANIMALS*

(Not including contents of the digestive tract)

	Water (Per cent)	Protein (Per cent)	Fat (Per cent)	Mineral Matter (Per cent)
Fat steer (wt. 1200 lb.) . . .	48.0	16.0	32.3	3.7
Dairy cow.	56.8	17.2	20.6	5.0
Mature horse	61.9	18.2	14.1	4.7
Fat sheep	46.2	13.0	37.9	3.0
Growing pig	66.8	14.9	16.2	3.1

The function of plant constituents in feeds. Each plant constituent, when consumed, has a special part to perform in the life process of the animal body.

Fibre is indigestible but is useful since it gives bulk or volume to a feed and helps fill up the animal.

Proteins are necessary for the growth and repair of muscles, cartilages, nerves, brain, internal organs (heart, lungs, etc.), hide, hair, wool, feathers, hoofs, nails, and horns. They are also essential for milk and egg production. There are many kinds of proteins; all of them contain nitrogen.

Carbohydrates supply heat and energy to the animal body and materials for the production of fatty tissue. They include sugar, starch, cellulose, and other compounds.

Fats are also sources of heat and energy and fat producing materials.

Mineral matter is required for bone building.

Vitamins have special functions in the health and growth of all farm animals. When first discovered they were regarded as mysterious substances recognizable only by their effect. However, a number are now known by their chemical composition,

*The data for the tables shown on pages 257, 261, and 402 were taken by special permission from *Feeds and Feeding*, (Abridged, 1947) by F. B. Morrison, published by The Morrison Publishing Company, Ithaca, New York.

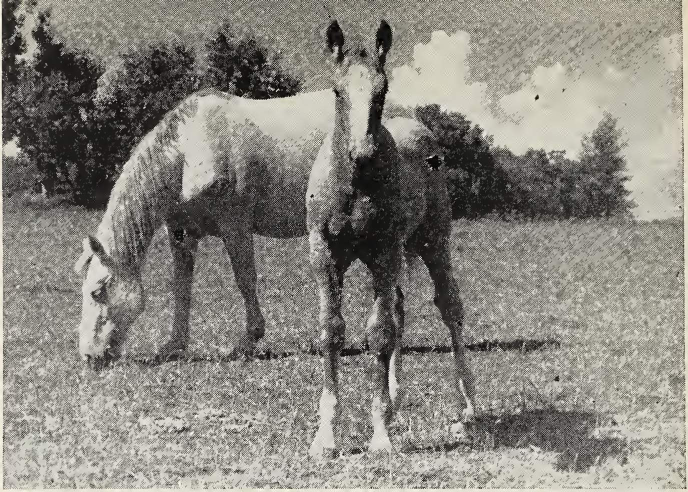


FIG. 191. This healthy colt has had, apparently, a good start in life. To continue to make thrifty growth, he must have, in common with all young animals, feeds rich in protein; minerals, especially calcium and phosphorus; vitamins; and total digestible nutrients. (Photo from L. H. Shaw)

such as vitamins A, B, C, D, E, and G. Animal life is impossible without them. They are particularly necessary for growing animals. Lack of vitamins in the animal body may cause such disorders and diseases as poor digestion, anaemia, and scurvy. Most of the vitamins are found in considerable amounts in the usual foods of man and beast.

Vitamins A and D are of great importance in feeding live stock —there is apparently no lack of the others in ordinary rations, except G for poultry. Vitamin A is necessary for maintenance, milk production, and reproduction of mature animals and for the growth of young animals. Vitamin D, sometimes known as the sunlight vitamin, is essential to prevent rickets, a disease affecting the bones of young animals, and for laying hens that spend long hours in a poultry house. The recently discovered vitamin K is needed by poultry but is apparently present in good quantity in the usual feeds.

The problem in feeding animals is to select and mix together such plants or parts of plants as will most efficiently and economically supply them with the materials required for maintenance of their bodies, growth, work, or the production of milk or eggs.

Digestion. An animal, when provided with a suitable selection of feeds, breaks them up by the processes of digestion and employs the most useful parts to build up the tissues of its body, to keep itself warm, and to produce energy for work; hence it is very important to supply the live stock of the farm with feeds that are suitable.

Digestible nutrients. *Nutrient* is the name given to any food constituent or group of food constituents of the same chemical composition, such as protein, carbohydrate, or fat, which may be used to nourish the animal body. Not all nutrients are digestible; digestible nutrients are those that can be digested by animals and taken into their bodies. The figures given on page 261 have been selected from a much longer table in *Feeds and Feeding*, Abridged 1947, by F. B. Morrison.

Exercise

Make a study of some of the common feeds used in Western Canada, using the table on page 261 as follows: Compare the amount of protein in the feed with the amount of non-nitrogenous nutrients, that is in the carbohydrates, fats, and mineral matter. This comparison is indicated in the table by the nutritive ratio. For example, buttermilk is rich in protein because its nutritive ratio is 1:1.8, that is 1 pound of protein to 1.8 pounds of non-nitrogenous nutrients. Feeds whose nutritive ratio is less than 1:6 are considered to be rich in protein. Those with a nutritive ratio of more than 1:6 are low in protein and rich in non-nitrogenous nutrients.

Concentrates. Concentrates are feeds that are low in fibre and rich in digestible matter.

Corn is an easily digested, palatable feed used a great deal in the United States for fattening cattle and hogs. Why is corn thus valuable? Corn is not suitable for feeding young animals, as it is low in mineral matter. Is there any other growth producing nutrient lacking?

Barley is used perhaps more than any other grain in Western Canada for fattening live stock. Why? When fed to cattle, horses, or swine, barley should be crushed or ground.

Oats are well balanced and, as a single grain, are the best for all kinds of live stock. Oats are used more than any other grain for horses. What is meant by saying that oats are well balanced?

Bran is the outer covering of the wheat kernel. It is quite bulky, and is more suitable for older animals than for young ones. Bran is used extensively for dairy cattle. Why? Since it is laxative, bran has a desirable effect upon the digestive system. It is sometimes used for horses, but it is too laxative to be a good concentrate for working horses.

Shorts or middlings are found between the outer layer or bran and the starchy part of wheat. They are valuable for feeding young pigs and dairy cattle. What makes them valuable for this purpose?

Oil cake or linseed meal is the residue of the flax seed after the oil has been extracted. When not too expensive, it is fed in limited quantities to dairy cattle, fattening cattle, horses, and lambs. Explain is what way oil cake is useful for each of the above mentioned farm animals. It is often used as a tonic to keep live stock in good health.

Skim-milk and buttermilk are both high in ash, and therefore are valuable for calves and young pigs. What other nutrient are they rich in which makes them important in growth producing rations?

Roughages for feed. Roughages are feeds which are high in fibre and low in digestible matter.

Legumes, such as alfalfa, clover, etc., are valuable muscle and tissue builders, and are especially useful for growing animals and dairy cows. Besides being high in mineral content, what other constituent are they rich in which makes them suitable for the above uses?

The leaves and the stalks of the entire corn plant form one of the most useful roughages. It is best stored as silage, in which state it supplies a very palatable, succulent (juicy) feed, high in nutritive value and easily digested. Silage is especially good for either beef or dairy cattle. Why?

COMPOSITION OF SOME COMMON FEEDING MATERIALS

	Total Dry Matter (Per cent)	Digestible Protein (Per cent)	Total Digestible Nutrients (Per cent)	Nutritive Ratio
Alfalfa hay	90.4	10.6	50.3	1:3.7
Brome grass hay	88.1	5.0	48.9	1:8.8
Sweet clover hay (second year)	92.0	10.5	49.9	1:3.8
Oat straw	89.6	0.9	44.1	1:48.0
Prairie hay	90.4	2.6	49.2	1:17.9
Timothy hay	88.7	2.9	46.9	1:15.2
Corn silage (well matured)	28.3	1.3	18.7	1:13.4
Turnips	9.5	1.3	8.5	1:5.5
Barley	90.4	9.3	78.7	1:7.5
Corn, grain	88.5	7.4	83.7	1:10.3
Oats	91.1	9.4	71.5	1:6.6
Wheat	89.8	11.3	83.6	1:6.4
Shorts	89.7	14.5	86.4	1:5.0
Bran	90.6	13.1	70.2	1:4.4
Oil cake (old process)	91.3	30.6	78.2	1:1.6
Skim-milk (centrifugal)	9.6	3.5	8.6	1:1.5
Buttermilk	9.4	3.3	9.1	1:1.8

Grasses are usually fed in the dried or cured state as hay. When grass or other green crop is cut and fed fresh, it is known as a soiling crop. Such crops are relatively low in protein, except when they are green and just before flowering time. Timothy is the best kind of hay to feed horses. Why is it unwise to include too much hay in the daily allowance of feed for dairy cattle?

Sunflowers have been found to be equal in food value to corn, and are favoured by many farmers because they grow better than corn in northern localities where growing seasons are shorter. But they cannot be used except as silage, and are not recommended except where corn cannot be grown.

Often, when hay and other roughages are scarce, oat straw may be used to replace them in rations for beef cattle or horses which are not working. It is most valuable when the grain has been cut slightly green, as it then has more food value and is more palatable than in later stages. Why is straw not suitable for rations for dairy cows in milk or for young animals?

Turnips and other root crops, such as mangels, beets, etc., are a very succulent feed. They are useful for sheep or beef cattle, but are not often fed to dairy cattle, as they are likely to produce an unpleasant flavour in the milk.

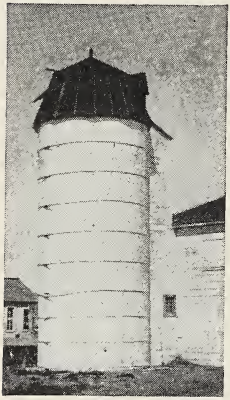


Fig. 192. A good type of silo.

The silo and silage. The silo is usually tall and cylindrical in shape. Its walls, constructed of wood, brick, or cement, should be vertical, smooth inside, strong, and air tight. The entire plants of the crops used—corn, sunflowers, oats mixed with peas, etc.—are first finely cut up, and then thoroughly tramped, to pack them tightly, as the silo is being filled.

The silo should be at least twice as high as its diameter, so that the silage will be deep and the upper layers will exert great pressure upon the silage below. The effect of this packing is to exclude the air from the material in the silo and thus preserve it for many months. Frequently, when the crop has become too mature or dry, moisture is added as the silo is filled. In this air-tight, moist condition, fermentation takes place, and the silage becomes acid in flavour and very palatable to the live stock.

The chief advantage of a silo is that it preserves the silage in such a condition that it provides a splendid substitute for pasture or green feed during the months of drought or winter. When fed to dairy cattle, silage encourages a large flow of milk. It has been suggested that, in parts of Western Canada, hay and oat

Fig. 193. Approximately one-half the feed eaten by farm animals is used merely to maintain the life processes of their bodies. Only when fed liberally and correctly beyond maintenance requirements can live stock be expected to fatten properly, yield milk abundantly, or work well. (Photo from Dominion Experimental Farms Service)

sheaves are cheaper than silage. But, in general, silage is an economical feed and is especially valuable for dairy cattle.

The pit or trench silo. Because tall, upright silos are expensive, may silos are now built below the ground. This, however, is more true of Western than of Eastern Canada. The pit silo should be lined with cement to prevent loss of succulence, though this is not essential to good silage. This type of silo has proved quite successful, its greatest disadvantage being the difficulty of removing the heavy silage from the pit.

Selecting a ration. A *ration* is the quantity of feed supplied to an animal in a day. In arranging a combination of the various feeds for an animal's daily allowance, it is essential to study carefully the composition, palatability, concentration, bulk, and succulence of each feed under consideration. Growing animals require feeds rich in vitamins. These growth promoting agents are found in the fat of milk, the thin leaves of plants, etc. The cost of the ration is another important consideration. Frequently it is necessary to substitute cheaper feeds for those being used. But under-feeding also reduces profits.

Maintenance rations. Before an animal can gain in weight or perform work, it must first secure from its ration sufficient materials for the upkeep and work of its body, such as moving about,

breathing, digestion, etc. For example, two-thirds of the average ration of a horse is used for digestion and bodily maintenance, leaving only one-third for external work. A maintenance ration is the amount of feed required per day to maintain an animal at rest so that it neither gains nor loses in weight. Such rations are frequently fed to live stock on the farm during the winter when no work is required of them.

Nutritive ratios. When animals are being fed for work, milk or egg production, or fattening purposes, they require much more food than for maintenance. The correct amount and proportion of various nutrients necessary may be found by calculating the *nutritive ratio*, that is, the proportion of digestible protein to the digestible non-nitrogenous nutrients. The method, as given in *Feeds and Feeding*, Abridged, 1947 edition, is as follows:

The percentage of digestible protein is subtracted from the percentage of total digestible nutrients to obtain the percentage of digestible non-nitrogenous nutrients.

The percentage of digestible non-nitrogenous nutrients is then divided by the digestible protein. The quotient is the second term of the ratio.

For example: a horse weighing 1600 pounds at hard work would require 19 pounds of brome grass hay and 18 pounds of oats daily. From the table on page 261, it is found that in 19 pounds of brome grass hay there are $\frac{5.0}{100} \times 19 = .95$ pounds of digestible protein and $\frac{48.9}{100} \times 19 = 9.29$ pounds of total digestible nutrients. By the same method the amounts of digestible protein and the total digestible nutrients in the oats may be calculated. Add these together and arrange as follows:

	Digestible Protein	Total Digestible Nutrients
Brome grass hay, 19 lb.	.95 lb.	9.29 lb.
Oats, 18 lb.	1.692 lb.	12.870 lb.
	2.642 lb.	22.160 lb.

Subtract the digestible protein from the total digestible nutrients and the difference shows $22.160-2.642=19.518$ pounds of digestible non-nitrogenous nutrients. Divide this figure by the protein, $19.518 \div 2.642=7.38$. The nutritive ratio of this ration is therefore 1 : 7.38; that is, 1 part of digestible protein to 7.38 parts of digestible non-nitrogenous nutrients.

Different kinds of animals require rations of different nutritive ratios. A nutritive ratio that is relatively rich in protein and low in non-nitrogenous nutrients is said to be a narrow nutritive ratio, and one that is high in non-nitrogenous nutrients and low in protein is called wide. It has been found by experiments that young animals and dairy cows require rations with a fairly narrow nutritive ratio for growth or milk production. Fattening cattle or working horses require rations with a fairly wide nutritive ratio for fat or energy.

Balanced rations. Feeding standards. A balanced ration is a mixture of feeds that will, without waste, meet the needs of an animal's body for twenty-four hours. Such a ration will return the greatest profit. Balanced rations are calculated by comparing them with feeding standards; but the method involves rather lengthy mathematical calculations, and is not employed by many practical farmers and stock men. Students who wish further information about balancing rations will find a fuller discussion on pages 401 and 403.

Rules for use in arranging rations. In order to assist the student in arranging practical balanced rations, the following rules are suggested:

Horses at work should be fed from 1 to $1\frac{1}{4}$ pounds of roughage and 1 pound of concentrates daily per 100 pounds live weight.

Dairy cows in milk will eat 2 pounds of good quality dry roughage or 1 pound of dry roughage and 3 pounds of silage daily per 100 pounds live weight, and about 1 pound of concentrates to every 3 to 5 pounds of milk produced.

Fattening cattle should receive 2 pounds or more of concentrates and dry roughage (or the equivalent in silage) daily per 100 pounds

FIG. 194. Dairy cows require rations well supplied with protein, minerals, vitamins A and D, and total nutrients.

live weight, the allowance of concentrates ranging from less than 1 pound to 1.7 pounds or more per 100 pounds live weight.

Fattening lambs will consume from less than $\frac{1}{2}$ to 2 pounds or more of concentrates and from $1\frac{1}{2}$ to $2\frac{1}{2}$ pounds of roughage.

Pigs can make but limited use of dry roughage.

It is suggested that students become to some extent familiar with the foregoing rules, at least, for feeding horses and dairy cattle, and with the other rules when they require them in actual practice. The cost of the ration should be kept in mind constantly. Protein is the most expensive food nutrient.

Quantities of oil cake to feed. The following quantities are suggested: for dairy cattle, from 1 to 2 pounds daily; for horses, from 1 to $1\frac{1}{2}$ pounds; for fattening cattle, from $\frac{1}{2}$ to $1\frac{1}{2}$ pounds; for lambs, $\frac{1}{5}$ pound; and for pigs, a small allowance in the daily ration.* The fact that oil cake is expensive should be taken into consideration.

Exercises

1. Calculate the nutritive ratio of the following ration for an 1800-pound horse at hard work; timothy hay, 19.8 pounds; and oats, 22.5 pounds. Is the nutritive ratio within the limits set by the Morrison Feeding Standards? (See page 402.) Is the ration balanced?

2. A cow not milking is being wintered on a ration of oat straw, 20 pounds, and oat chop, 8 pounds. Find the nutritive ratio of this ration.

3. What difference would the addition of $\frac{1}{2}$ pound of oil cake make in the nutritive ratio of the ration in Exercise 2?

4. Consult the *List of Publications* of the Department of Agriculture, Ottawa, and other publications. In the live stock section you will find listed a number of bulletins which discuss the feeding of the various classes of farm animals. Send for these publications, and, after studying them, arrange other balanced rations.

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*In part from *The Book of Live Stock*, by Wade Toole.

The teeth of farm animals. When buying sheep, it is important to examine the mouth of each one to see that the teeth are in good condition. It is a good plan also to have horses' teeth examined occasionally for the same purpose.

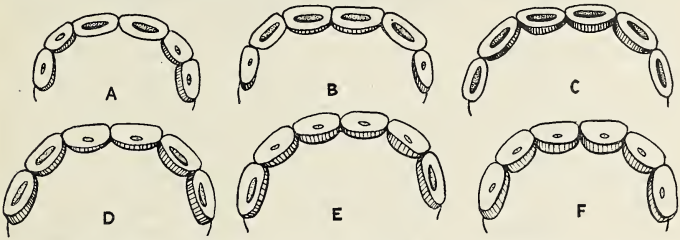

FIG. 195. Dentition in horses. The teeth of (*a*) a three-year-old, two permanent incisors; (*b*) a four-year-old, four permanent incisors; (*c*) a five-year-old, six permanent incisors; the incisors appear in pairs as outlined, in both upper and lower jaw at the same time; (*d*) a six-year-old, the cups have disappeared from the central pair of incisors in the lower jaw; (*e*) a seven-year-old; (*f*) an eight-year-old, the cups have gone from all incisors in the lower jaw; (*g*) at nine years the cups disappear from the central pair of upper incisors, at ten years from the next pair, and at eleven years from the outside pair.

The age of some animals can be determined by an examination of their teeth. (See Figures 195 and 201.) The number of teeth which the various farm animals have is shown in the table on page 268, which should be used only as a reference.

The essential features of a stable. From the standpoint of labour, the stable should be planned for convenience. For the animals, cleanliness, light, ventilation, dryness, and warmth are necessary. The stable should not be too warm, and there should be a good supply of fresh air. On the other hand, a cold stable is not always well ventilated. Proper ventilation requires an arrangement for the free exchange of impure air from inside for fresh air from without. It is a good plan to whitewash the stable at intervals, using a five per cent solution of carbolic acid in the whitewash.

Cheaper shelters. Barns do not have to be expensive. Costly shelters do not always return interest on the money in-

THE TEETH OF FARM ANIMALS					
ANIMAL	JAW	INCISORS OR CUTTING TEETH	CANINES	MOLARS OR GRINDING TEETH	TOTAL
Horse	Upper	6	*2	12	
	Lower	6	*2	12	40
Cow	Upper	a tough pad only	0	12	
	Lower	8	0	12	32
Sheep	Upper	a tough pad only	0	12	
	Lower	8	0	12	32
Pig	Upper	6	2	14	
	Lower	6	2	14	44
Dog	Upper	6	2	12	
	Lower	6	2	12	40

vested, but suitable protection will return profitable dividends. It has been demonstrated by practical stock men that cattle, sheep, and hogs do well even in winter in inexpensive, partially open shelters. The walls of such shelters may be constructed by supporting two rows of woven wire or poles, and filling the space between with straw; and a suitable roof may be made of straw supported by poles. The shelters are usually open on the south side. Dryness is essential. The low temperature and open air promote good health and vigour in the stock. (See Figures 199 and 200.) (For problems and suggestions on the cost of sheltering farm animals, see pages 354 and 355.)

The care and feeding of horses. The colt. The essentials of successful colt-raising are cleanliness, exercise, fresh air, and proper feeding. The colt should be taught early to eat grain, and should be weaned at from four and a half to six months of age. The

*Usually absent in female.

object in feeding is to keep the colt growing steadily; it should not become fat. It is advisable to feed often, and to use good muscle and bone building feeds. A little salt, plenty of clean bright hay, and pure water are necessary. While it is quite young the colt's education should commence. Its feet should be trimmed at intervals as required.

The farm work horse. A horse is fed to produce energy. The daily allowance of feed depends upon the type of work that the horse is required to do. Oats are the best concentrate, although ground wheat or other cereal may form part of the grain ration. The roughage should consist of oat sheaves, bright clean prairie or cultivated hay, clover, or alfalfa. (See the rule given on page 265 for suggestions of the amounts to feed.) The digestive system of a horse is very sensitive and is easily put out of order. For this reason great care should be taken not to feed any mouldy or dusty hay. Caution should also be observed when watering. After hard work or fast driving, the horse should not be allowed to drink a large quantity of water until he is cool. It is also important to reduce the concentrates of the ration when the horse is idle for a few days. Failure to do this often results in indigestion and sometimes in death. During the winter, horses should be fed for maintenance only. Roughage can be used for most of the ration, but a few pounds of grain may be necessary to keep the animals in good condition. Work horses should be hardened for spring activities by putting them on better feed about a month before work in the field commences. The first grain ration should be small, the amount being gradually increased to full allowance. The horse should be fed regularly. A variety of feeds will give good results, although sudden changes in the kind or amount of feed should be avoided, as these are very likely to cause serious digestive troubles. There should be some rock salt in the mangers at all times.

Great care should be taken to have the harness, especially collars, fitted properly to prevent sore shoulders, etc. Bathing the shoulders with cold salt water to toughen them is a good

practice, especially before commencing work in the spring, when the shoulders are soft and tender after an idle winter. The horse's feet should be trimmed carefully and often, to prevent them from growing out of shape. At night, after a hard day's work, the horse should be thoroughly groomed as soon as he is dry, in order to keep his hide in a healthy condition. When on pasture, as well as during periods of work, he should be protected from flies.

The feeding and care of dairy cattle. The calf is usually removed from its mother one or two days after birth, as in most cases it is more profitable to separate the mother's milk, sell the cream, and feed the skim-milk to the calf. The calf should be taught to drink from a pail at once. The change from whole milk to skim-milk should be gradual, and it is a good plan as the quantity of whole milk is reduced, to substitute something for the cream. For this purpose flax seed jelly is recommended. Calves should be fed three or four times a day at first, and should gradually be reduced to two feedings daily when they are about three weeks old. Milk should always be fed as soon as possible after being drawn from the cow and at a temperature of from 90° to 100° Fahrenheit. When about three weeks old, the calf should be taught to eat a small quantity of oats, bran, oil cake, or pulped roots. Nothing is better than legume hay, since it is rich in protein and mineral matter. The amount of grain should be increased gradually, feeding each time just what the calf will quickly clean up. At about five or six months, the calf should be put on a grain and roughage ration entirely. Plenty of fresh water and some salt should be provided. Over-feeding, cold sour milk, and unclean pails cause most of the trouble experienced in feeding calves. The calf should be kept in a clean, dry, warm place and given reasonable exercise and plenty of sunshine.

In feeding the dairy cow, the object is to produce milk, not to fatten the cow. The feed should be palatable, succulent, easily digested, and abundant. Cattle (and sheep and goats) are *ruminants;* that is, they chew the cud. These animals have

four stomachs. Food is first swallowed in partially masticated form. From the first stomach, or paunch, the food passes to the second one, from which it is returned to the mouth, chewed again, and reswallowed, passing to the third and fourth stomachs. The fourth is the true stomach, in which the food is acted upon by digestive juices. The nature of the ruminant's digestive system makes it necessary to include in its ration a large amount of bulky food. Feeding should be regular with regard to both the time and the character of the feed. Clover and alfalfa are excellent dry roughages with grain, and constitute cheap sources of the protein which is necessary to balance the rations of the dairy cow. When the roughage is hay or oat sheaves, some feed rich in protein, such as oil cake or bran, is required; but these materials are expensive in comparison with the cost of home-grown feeds such as legumes, hay, etc. Pasture should be provided in summer; and when pasture is not available, roots, silage, or green feed should be included in the rations. There should be a variety of feed. (See page 265 for suggestions regarding the amounts to feed.) The individual appetite of each cow should be considered; what will be satisfactory for one cow may be of little value for another. Water and salt should be available at all times.

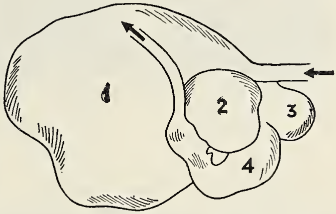

FIG. 196. The digestive system of a cow, showing the necessity of feeding cattle a large amount of roughage. The stomach and intestines of a cow have almost twice the capacity of those of a horse.

Cows should be cleaned and groomed regularly, and should be milked at regular hours, at least twice daily. DDT stock sprays, designed to kill and repel blood-sucking insects, may be used to protect the cattle both in the field and in the barn and thus prevent reduction of milk yield during fly time.

The management of a dairy herd. As we have already said, to produce the maximum yield of milk, dairy cows should be fed

Fig. 197. The dairy recorder weighs, samples, and tests the milk of each cow at the time of his monthly visits. What are the advantages of a cow testing programme? (Photo from Saskatchewan Film Board)

properly and milked regularly. The cows themselves should be large and of high milk producing ability. Milking qualities are inherited (see page 286) and cannot be developed in cows whose ancestors were poor milk producers. A sire of good type, from a family of heavy producers, is essential. A good sire has more influence than any other member of the herd on the quality of the offspring. (See page 286.) By the use of a good sire, it is possible, within the space of a few years, to develop from cows which are only fair, a herd of heavy milkers. It is important to determine the milk and butterfat production of each cow, by means of individual weighing and testing. A knowledge of the total production of a herd means very little. A few of the cows may be yielding most of the milk. The good cows should be selected to build up the herd, and the unprofitable ones discarded.

Cow testing is conducted as follows: (1) The milk of each cow is weighed accurately three times a month, on the 5th, the 15th, and the 25th, both morning and night. (In many cow testing programmes the practice is to weigh the milk every day and not just a few times a month.) (2) Samples are taken each time and are either tested at once or are placed in a bottle with a preservative to prevent them from spoiling, and the composite sample is tested at the end of each month, to determine the percentage

of butterfat. (3) Careful records should be kept of all weighings and tests. (4) The test should be conducted for the entire lactation period. A cow may produce a large quantity of milk for a short time, but the most profitable cow is the one that milks heavily for ten or eleven months, producing at least twelve to fifteen quarts per day. The average annual production per cow in Canada is about 4500 pounds of milk, or 180 pounds of fat, but the better cows produce from 6000 to 7000 pounds of milk and upwards, or 300 pounds or more of butterfat. Yields of 10,000 to 15,000 pounds of milk a year per cow in a regular commercial herd are no longer uncommon.

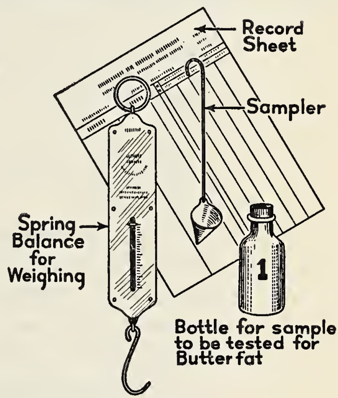

FIG. 198. Cow testing apparatus. For the Babcock test apparatus, see page 293.

Each cow's record should be studied carefully, so that at the end of the year the poor producers, if there are any, may be weeded out. If tests for butterfat cannot be made, there is value in recording only the weight of the milk produced by each cow.

The Saskatchewan Department of Agriculture provides a free cow testing service, known as the "Cow Testing Centre Plan." Under this plan, the dairyman is responsible for sampling and weighing the milk of each of his cows; the Department arranges for the testing of the samples each month at an official testing centre, and prepares monthly and yearly statements of the milk and butterfat production of each cow.

Dairymen and others who are interested in cow testing should write for further information to the Department of Agriculture of the province in which they reside.

Herd Improvement Associations. Another service furnished by the Saskatchewan Department of Agriculture is the promotion and supervision of Herd Improvement Associations. A dairy recorder visits each herd in each association monthly. He remains

Fig. 199. A sheltered and well bedded feed-lot. Maximum gains cannot be expected unless cattle are well fed and comfortable. (Photo from Dominion Experimental Station, Lethbridge)

for about twenty-four hours and weighs and tests the milk of each cow. Records are kept for a period of 305 days, and certificates of production are issued by the Dairy Branch when the requirements set forth below have been fulfilled. Each cow's butterfat production must equal or exceed the standards shown in Table A on page 275 for a 305-day period for the ages indicated.

Seals of merit are attached to the certificates as shown in Table B on page 275.

Record of Performance. Record of Performance (R.O.P.) registration is conducted by the Dominion Department of Agriculture. All animals must be pure-bred and registered in the Canadian Herd Book. The test is not carried on for more than 365 days. The owner must weigh all milkings of each cow, keep a record in a conspicuous place in his stable or milk house, and report his records each month. A government inspector visits each herd as frequently as possible during the year at irregular, unannounced times. He must remain for at least one full day, covering all the milkings of the whole period at each visit. Production requirements for 365 days for R.O.P. registration vary according to breed; they are in part as shown in Table C on page 275.

The feeding and care of beef cattle. The first summer the beef calf is fed on milk or allowed to run with its mother. For a beef calf raised by hand, practically the same methods are recommended as were outlined for the dairy calf. During the first winter it should be given roughage and a small allowance of grain. The second summer it should be pastured, and then fattened during the next winter. Beef steers are marketed, as yearlings, two-year-olds, and three-year-olds.

TABLE A—STANDARDS OF BUTTERFAT PRODUCTION SASKATCHEWAN HERD IMPROVEMENT ASSOCIATIONS

Age	Butterfat	Age	Butterfat
Mature cow	360 lb.	3-year-old	277 lb.
4-year-old	317 lb.	2-year-old	252 lb.

TABLE B—STANDARDS FOR SEALS OF MERIT SASKATCHEWAN HERD IMPROVEMENT ASSOCIATIONS

Age	Gold Seal	Red Seal	Blue Seal
Mature cow	600 lb.	500 lb.	400 lb.
4-year-old	528 lb.	440 lb.	352 lb.
3-year-old	462 lb.	385 lb.	308 lb.
2-year-old	420 lb.	350 lb.	280 lb.

TABLE C—PARTIAL R. O. P. STANDARDS
(365-Day Division)

Breed	Age	Milk	Butterfat
Ayrshire	2-year-old	7000 lb.	280 lb.
	mature cow	10000 lb.	400 lb.
Guernsey and Jersey	2-year-old	5500 lb.	275 lb.
	mature cow	8000 lb.	400 lb.
Holstein	2-year-old	9000 lb.	306 lb.
	mature cow	12000 lb.	408 lb.
Shorthorn	2-year-old	5000 lb.	190 lb.
	mature cow	6500 lb.	247 lb.
Red Poll	2-year-old	5000 lb.	200 lb.
	mature cow	8000 lb.	320 lb.

Fig. 200. A well planned lamb feedlot. Note the plentiful supply of bedding and the protection provided against winds and storms. (Photo from Dominion Experimental Station, Lethbridge)

"Fed calves" is the term applied to cattle that are finished and marketed under eighteen months of age. They should be left with the dam for five or six months and fattened as they grow. Towards the end of the feeding period, they should receive a good grain ration.

The object in fattening cattle is not the accumulation of fat, but the improvement in the quality of the meat by the depositing of fat through the lean meat tissue. Most cattle are fattened before they are fully matured (two to three years old), in order to take advantage of increased weight through growth. One of the most profitable methods of fattening cattle is to buy them on the market in the fall, when cattle are coming in from pasture (possibly from ranches in south-western Saskatchewan) and prices are relatively low, fatten them during the winter (usually for about six months), and sell them in June, when prices are usually fairly high. To make a profit in this way, it is necessary to have an increase in price as well as in weight. Cattle should be dehorned before feeding is commenced. It is usual to begin feeding with a light ration and to increase the allowance to the full amount in about six weeks. (See page 265.) Salt should be supplied. The best grains are barley, wheat, and oats, supplemented by linseed meal. Legumes, green oat sheaves, and prairie and cultivated hay are suitable roughages. The cattle may be winter-fed either in the barn or out-of-doors; both methods have advantages. (See page 267.)

Marketing beef cattle. For marketing, it is important to have the cattle finished in the right condition and at the time when prices are highest. If they are ready too soon, the extra feed consumed reduces the profits; and, if they are not finished on

time, they have to be sold when they are too thin or after prices have gone down. Many of the beef cattle produced in Canada are exported to Great Britain or the United States. There is usually a good demand in these countries for live Canadian cattle, both finished and feeders. Feeders and stockers are cattle which are purchased to be taken back to the farms for further feeding and fattening.

The feeding and care of sheep. Sheep, more than all other farm animals, must be kept dry. Shelter may be very inexpensive, as sheep can withstand a great deal of cold as long as they are not wet. The danger is that they may be kept too warm during the winter, although they should not be exposed to draughts. Plenty of exercise is essential.

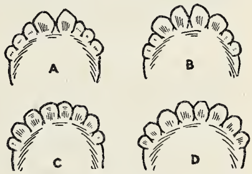

FIG. 201. The teeth of sheep. (*a*) Twelve to fifteen months old, two central permanent incisors. (*b*) Two years old, four permanent incisors. (*c*) Three years old, six permanent incisors. (*d*) Four years old, eight permanent incisors. (See page 267.)

Barley and oats are the best grains for sheep, and should be fed whole. The roughage should consist of good quality legume hay, prairie or cultivated hay, or oat sheaves. Hay should be fed in racks and not on the ground. Turnips and alfalfa make excellent winter feeds. Over-feeding should be avoided. Salt should always be available. Sheep are the weed scavengers of the farm, and may be profitably pastured on weedy summerfallows. Fields where sheep are grazing should be enclosed by woven wire fences.

At lambing time, sheep require the constant attention of the shepherd to prevent loss. The ewe will often neglect the lamb if the shepherd is not near. Lambs should be taught early to eat grain, by the use of a "lamb-creep." They are weaned at from four to five months of age, and should have an abundance of good pasture during the summer. All lambs should be docked when they are two or three weeks old.

The flock should be clipped as soon as the weather is warm, usually during the latter part of May in Eastern Canada and the

early weeks of June in Western Canada. Clipping should be followed in a week or two by dipping, which consists in immersing the sheep in a creoline solution or specially prepared sheep dip, to destroy the lice, keds, and ticks that may infest them. A more recent method is to spray the sheep with a high-pressure sprayer. When it is time to fatten the sheep, quiet and regular feeding are necessary. Lambs should be put on a full ration gradually. Lamb and mutton may be rail graded. (See page 253.)

The care and feeding of swine. Next to the dairy cow, hogs produce more human food per pound of feed consumed than any other farm animal. Hogs should be ready for market at about six months of age, when they should average about 200 pounds in weight; or, to be more exact, they should weigh from 190 to 220 pounds when they arrive at the stockyards. To secure the best bacon, it is necessary to start with the right type of hog. (See page 252 for market standards.)

Pigs are weaned when they are about eight weeks old. Two or three weeks after birth, they should be taught to eat a thin mixture of grain and skim-milk. This should be placed in a shallow trough in a "creep" to prevent the old pig from reaching it. A good grain is ground oats from which the hulls have been sifted. Pigs continue to grow up to the time they are marketed, and for the most profitable results should be fed muscle and bone building feeds. Shorts, green feed, a protein supplement like skim-milk, and some mineral rich feeds are required in the ration. Large amounts of barley, unsupplemented, should not be fed to pigs, as it tends to fatten them too much. When the pigs are about four months old, the quantity of skim-milk may be reduced and the quantity of grain increased. Fresh water should always be available. Hogs should be fed regularly, usually twice a day but overfeeding must be avoided. Sunshine and access to clean earth encourage good health. Plenty of exercise at all times is essential; and for this purpose an alfalfa pasture is ideal. Pens and yards should be kept as clean as possible.

A FEW DISEASES OF HORSES AND CATTLE

Animals, like people, are subject to many diseases some of which are infectious. However great progress has been made in veterinary science which deals with diseases of animals. Vaccines and serums are now available which produce resistance to encephalomyelitis, influenza, contagious abortion, hemorrhagic septicemia, and other diseases. Sulphur drugs have been effective in some cases. To supply phosphorus, iodine, and other elements essential to health, when these are lacking in feeds due to soil deficiencies, special soil fertilizers have proved valuable. Artificial food supplements will supply vitamins A and D. The latter have value in the prevention of certain diseases.

It must be emphasized that the control of animal diseases requires definite and effective co-operation between live stock men, government officials such as the local agricultural representative, practising veterinaries, and veterinary research laboratories.

The following paragraphs deal with only a few diseases of horses and cattle.

Equine encephalomyelitis. This is a disease of horses, sometimes referred to as sleeping sickness. It is caused by a virus (so small that it will pass through a fine porcelain filter) which locates in the brain. The disease is transmitted from infected to healthy horses by mosquitoes and other biting insects and is communicable to humans.

Symptoms are either dullness, in which case the horse may stand for hours, head held low, front feet spread apart; when walking, the animal moves with an unsteady gait; or nervousness, in which case it stands quietly with head pressed against some solid object, then suddenly becomes excited and violently active. Later, paralysis, particularly of the hind legs and throat, develops. If these symptoms continue, death occurs.

Encephalomyelitis may be prevented by annual vaccination during April and May. In Saskatchewan, the vaccine may be secured from The Animal Diseases Laboratory at the Univer-

Fig. 202. The development of the drug phenothiazine has minimized damage caused by nodular worms in sheep. The lamb carcass on the right shows the effect of nodular disease caused by young worms in the intestines. Compare with the healthy one at the left. (Photo from Canadian Industries Limited)

sity. For treatment, anti-encephalomyelitis serum should be used as early as possible after the disease is recognized; however, the value of the serum at any time is doubtful, and it is definitely negative after marked symptoms have developed.

Swamp fever. Swamp fever, or infectious anaemia, of horses is caused by an ultra-microscopic organism or virus. It is transmitted from horse to horse by biting insects, such as the horse fly, stable fly, and certain mosquitoes, and may also be contracted by drinking slough water.

The symptoms are as follows: The horse is suddenly unable to perform his usual work; there is no appetite; breathing is rapid. Later, the horse becomes thin and weak, and walks unsteadily. The mucous membranes of the mouth, eye, and nose become anaemic. The temperature may be 101° to 106° Fahrenheit. The pulse becomes rapid and weak. In advanced stages of the disease, the animal will stand for hours in one position. Finally, the horse becomes too weak to stand and death follows.

Prevention is of much more value than treatment. Swampy pastures and watering places should be avoided. If slough water

must be used, it should first be passed through a pipe containing lime. Horses known to have had the disease should not run with healthy horses during fly season. Giving horses protection from flies has value.

Blackleg. Blackleg is an infectious disease of cattle of which the first indication of an outbreak is usually the discovery of one or more young cattle dead. The disease is caused by a germ which produces gas resulting in the appearance on various parts of the body of swellings that crackle when pressed with the fingers. An infected animal remains by itself. Its breathing is rapid and laboured, its temperature high, and lameness is evident. Finally, the animal dies in a state of coma. Another disease, malignant edema, has every appearance of blackleg. The two can only be distinguished by a laboratory test.

Blackleg is another disease in which preventive measures are all important in control since there is no effective treatment. When an outbreak occurs, the bodies of dead animals should be buried six feet deep together with all contaminated materials. Articles that cannot be buried should be thoroughly disinfected. Cattle should be vaccinated until three years of age—annual vaccination each spring is necessary when older types of vaccines are used, but a newer type is available that gives life-long protection from one vaccination.

Both blackleg and malignant edema germs are found in the soil and on the forage in many cattle-raising areas. For this reason, stock men are being urged to use the combination vaccine which carries immunity for both diseases.

Contagious abortion or Bang's disease of cattle. This is a highly infectious disease, caused by a microscopic organism that enters the bodies of cattle through the skin and by contaminated feed and water. It was demonstrated in 1920, that the disease may be transmitted to man through handling infected cattle or drinking contaminated milk. In man it is known as undulant fever. Bang's disease is very widespread in both Canada and the United States; it causes severe financial loss every year.

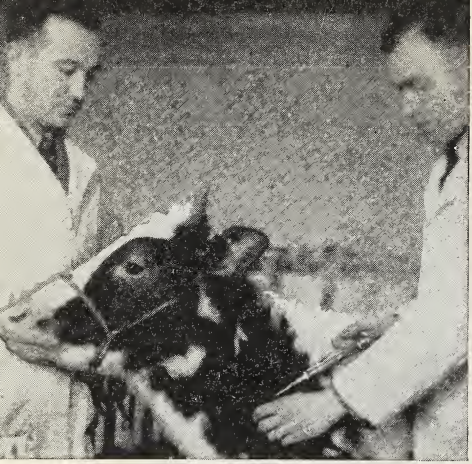

FIG. 203. The introduction of an effective vaccine has made possible the production in calves of resistance to contagious abortion. Developments such as this, together with governmental co-operation, have done a great deal to assist farmers in keeping their live stock free from disease. (Photo from Canadian Industries Limited)

A herd of cattle may become badly infected before the disease is recognized. Some symptoms are premature births and a general unthrifty condition. However, only by laboratory testing of blood from suspected animals can it be determined whether infection has occurred.

While many encouraging results have been obtained at the Ontario Veterinary College and elsewhere from the use of penicillin, it seems to be still agreed that there is no satisfactory or completely dependable cure. Preventive measures should be taken. All newly purchased cattle should be tested before being introduced into a disease-free herd. When an animal becomes infected, the entire herd should be tested. Infected cows should be removed from the herd, their stalls thoroughly disinfected, and all litter and feed in the stalls burned. Calfhood vaccination of heifers between four and eight months of age has proved effective. By vaccinating heifer calves a "Bang's free" herd may be built up. When suspected outbreaks occur, a veterinary should be consulted.

Hemorrhagic septicemia. This condition occurs among cattle, horses, sheep, and pigs.

In cattle this disease is commonly known as shipping fever because it is usually induced by some definite upset in the animals' routine such as is occasioned during handling and shipping; but it may also occur on the range where no handling has taken place. The disease may affect different organs of the animal: pulmonary (lungs and air passages), intestinal—this is not common, cerebro-

spinal (brain and spinal cord), and cutaneous (skin and adjacent tissues).

The symptoms are as follows: a rise in temperature; loss of appetite; soft swellings on the throat and dewlap; difficulty in breathing, blood stained discharge from nostrils and mouth; sometimes muscular tremblings; inflamed watery eyes; sometimes diarrhœa; the animal may stand with legs wide apart with a gaunt, tucked up appearance.

Treatment of cattle is not very satisfactory. In the early stages, treatment with anti-hemorrhagic septicemia serum or one of the sulpha drugs has value. One or two vaccinations ten days prior to shipping sometimes but not always affords protection.

Bloating of cattle. Bloating is caused by a digestive disturbance. It is characterized by rapid and progressive distension of the left flank which becomes tense and drum-like. The animal is restless, crouches, stamps its feet, and kicks at the abdomen. Respiration becomes distressed and laboured. Unless speedily relieved, the animal staggers and falls, death occurring from suffocation in the space of from thirty minutes to two or three hours.

Bloating often occurs when animals with an empty stomach are put on legumes, such as clover or alfalfa, particularly when the plants are damp as they sometimes are in the morning.

Relief is afforded by tapping the stomach to permit the escape of the gas causing the distension. A special instrument, called a trocar and cannula, should be used. The puncture is made on the left side at a point equidistant from the last rib, the point of the hips, and the side projections of the backbone. Daily doses of mineral oil or raw linseed oil are helpful.

Most digestive troubles of cattle and other live stock can be prevented by proper feeding and watering. There should be good quality feed and regularity of quantity and time of feeding.

Pests. Live stock are subject to certain parasites, such as stable fly, house fly, black fly, horn fly, bot fly, warble fly, sheep ked, ticks, and tape worms. These cause serious loss in several ways. Study live stock parasites. Which are prevalent in your locality?

Exercises and Problems

1. The feeding and care of the different classes of farm animals may be summarized under several headings: (*a*) general principles, such as ventilation, cleanliness, etc., which apply to all classes; (*b*) rules for the amount of feed, (page 265); (*c*) feeds suitable for the particular animals being discussed; (*d*) special considerations, such as the harness and the feet of horses, the milking of dairy cows, the shearing and dipping of sheep, etc. Make out such a summary for horses, dairy and beef cattle, sheep, and swine.

2. Enquire of live stock men in your district where they market their stock.

3. Clip from the daily papers several live stock market reports. Learn the names of the grades of cattle and hogs listed. Which grades sell for the highest prices? If you do not understand what the names of the grades mean, ask a live stock man to tell you about them.

4. Investigate the newer type of dairy barn in which cows are not being confined at any time except when being milked. Tests are now under way at the Lethbridge Experimental Station to compare the "stanchion" and "loose housing" stables.

Projects

1. Students should be encouraged to engage in a practical live stock project, such as the feeding of well bred colts, calves, sheep, or pigs. Stock judging competitions should be organized. When suitable arrangements can be made, feeding experiments should be conducted. Animals, owned and fed by the students, should be exhibited at various fairs. If the teacher cannot undertake this work, there is usually someone else in the community who can be persuaded to assume the responsibility.

2. At the time of such fairs as the Royal Winter Fair, held in Toronto, and the International Live Stock Exposition, held in Chicago in November and December, as well as the various summer fairs, watch newspapers, etc., for announcements about the success of live stock men from your own province and community.

CHAPTER 13

THE IMPROVEMENT OF FARM ANIMALS—THE VALUE OF LIVE STOCK—LIVE STOCK PRODUCTS

THE IMPROVEMENT OF FARM ANIMALS

The production of better live stock is based upon the same principles of variation, heredity, and selection as those that underlie plant improvement. (See page 162.) Crossing is also practised to some extent with live stock but is employed chiefly to produce animals for special purposes.

Exercise

Define or explain the following terms with special reference to animal life, giving examples in each case: variation, variation due to environment, variation due to crossing, mutation, selection, natural selection, and artificial selection.

Heredity. Heredity is the most important factor in the development of good live stock.

Exercise

Among some live stock, observe several parent animals and their offspring with the object of noting peculiarities of conformation, colour markings, size, disposition, etc.

Your observations will show that offspring, in the majority of cases, more or less closely resemble their parents. If the parents are deep, wide, and lowset in conformation, these qualities are transmitted to the offspring. The transmission or passing down of characters from parent to offspring is known as *heredity*. All the characters possessed by an animal must have been present in some one or other of its ancestors. The proportion in which the inheritance of characters occurs is considered to be as follows: fifty per cent from the parents, twenty-five per cent from the grandparents, twelve and a half per cent from the great grand-

parents, and so on. In breeding live stock therefore, we produce, not animals with new characters, but animals possessing characters previously present in some ancestor. Unless the ancestors have been good individuals, it is impossible to produce good qualities in the offspring. Undesirable characters, such as poor conformation, weak constitution, etc., are just as surely and as frequently inherited as good qualities.

Selection. Since both good and bad qualities of parent animals are inherited by their offspring, it is plain that the successful breeder must practise the most rigid selection in the choice of the animals that he mates together. Poor animals, carelessly selected, will produce poor animals; while animals of good type, conformation, and ability will produce offspring possessing these good qualities.

For example, a dairyman who wishes to breed good dairy cattle must keep only cows of high milking ability and lean wedge-shaped conformation, from which to raise calves; good milking qualities are inherited and cannot be developed to any extent in a cow, unless they have been present in her ancestors.

A "top-grade" bacon hog weighing 200 pounds can be sold for 8 cents a pound, or $16.00, while a larger hog of the thick type weighing 240 pounds can be disposed of for only 6 cents a pound, or $14.40, that is $1.60 less. Both hogs require the same amount of feed and care, but one is correct in type and meets the requirements of the market, and is therefore worth more than the other. The characters of the top-grade bacon hog are inherited, and breeders who carefully and intelligently select the right type of parent can produce bacon hogs much superior to those produced by breeders who do not make such a selection.

The importance of a good sire. Since, in herds or flocks of farm animals, there are usually several females and one male or sire, it is evident that, while each female transmits her characteristics to only one of the offspring, all of the offspring inherit characteristics from the male. Thus the male has the greatest influence upon the improvement or retrogression of the herd or

flock, and he should, therefore, be the best animal that the breeder can possibly afford.

Registered pedigreed stock. Pure-breds. It sometimes happens that when two good animals are mated together, inferior qualities not visible in either parent appear in the offspring. Where do these undesirable characters spring from? They have been inherited from the grandparents or great grandparents, as stated on page 285. To guard against this occurrence as far as possible, it is necessary for the breeder to know the ancestry of his breeding stock. For this purpose records, known as pedigrees, have long been maintained by breeders of good live stock. To be official, pedigrees, with the exception of those of Holstein-Friesian cattle, must be registered with the Canadian National Live Stock Records Association, Ottawa.

THE EXTENDED PEDIGREE OF A SHORTHORN BULL

Star of Hope =122595= Date of birth, Nov. 2nd, 1917. Bred by J. G. Barron, Carberry, Man.	Emma's Prince =95009=	Missie's Prince	=83660=
		Emma of Oak Bluff	=99707=
	Rosa Hope's Pride =102936=	Scotch Thistle	=72489=
		Rosa Hope 18th	=84447=

A *pure-bred* is an animal with an official pedigree, which proves that all its ancestors have been members of the same breed for many generations.

Crossing. Crossing means the mating of two individuals of different breeds. For example, on the range, Shorthorns and Herefords are sometimes crossed to produce steers with the smoothness and size of the former and the constitution and rustling ability of the latter. These cross-bred animals have been produced in this way to give them qualities for which they can be sold more profitably. They would not be useful for breeding purposes, as they possess the blood lines of two different breeds. Neither would it be possible to foresee what characteristics the

offspring would inherit. Better results are usually obtained by mating together pure-bred animals, as Shorthorn with Shorthorn, Yorkshire with Yorkshire, etc. At the same time the student should watch the farm press for articles describing the results of cross-breeding; some of the results of recent cross-breeding have been extremely interesting.

Scrubs. Grades. Grading-up. A *scrub* is an animal without a recorded pedigree, that is, its breeding has not been methodically improved. Such animals are usually very poor and undesirable. A *grade* is an animal with one pure-bred parent and one unimproved parent. When a herd of scrub cows is headed by a pure-bred sire, the offspring are grades. The practice of mating unimproved stock with improved pure-bred animals is known as *grading-up*. Usually pure-bred sires are mated with unimproved females. When this is done for several generations, the unimproved blood gradually disappears from the offspring, and, while the offspring will not be pure-bred, valuable improvement will result. (See diagram on this page.)

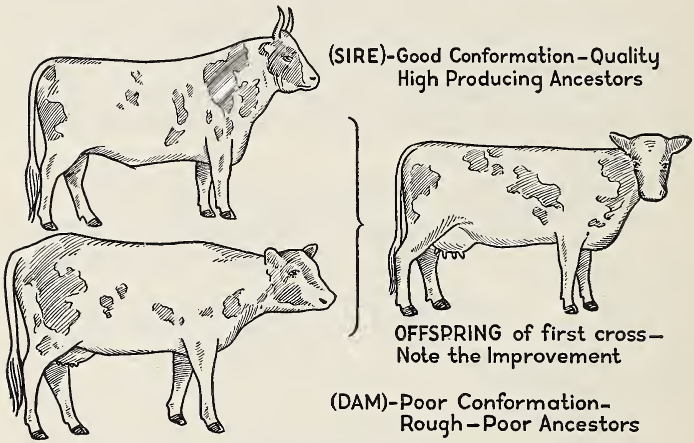

FIG. 204. The value of a good sire in improving a dairy herd.

Exercises

1. Distinguish between the terms pure-bred and Thoroughbred as applied to live stock. Give examples.
2. Secure a pedigree from a breeder, and make a copy of it.
3. What suggestions, other than those of feed and care, would you make to a farmer who wishes to improve the milk yield of his herd of grade cows or the quality of his beef cattle, draft horses, etc.? Give reasons for your recommendations.

Project

Make a survey of the live stock of your district. Prepare a list of the pure-bred cows and their milk records, and compare them with those of the scrub cows. Are there any scrub sires? How many pure-bred sires do you find at the head of grade herds? How many pure-bred sires heading pure-bred herds? Decide whether the quality of the live stock in the district is improving or not.

THE IMPORTANCE OF LIVE STOCK IN FARMING

All who understand the business of farming agree that live stock are necessary to the successful practice of agriculture.

The advantages of raising live stock are as follows: When part of the farm is used to raise live stock, the manure may be applied to the soil to restore the fibre destroyed by grain-growing; thus the danger of soil drifting is reduced, and the fertility of the soil is maintained. Live stock are a source of revenue; thus they reduce the risk of farming—the farmer who raises live stock has an income even if his crops fail. Animals on the farm are valuable since they make use of otherwise wasted products; skim-milk may be fed to calves and pigs; sheep may be kept on weedy summer-fallows; damaged or low grade grain that has little value as grain may often be used to feed cattle or pigs. The coarser grains, such as barley and oats, grasses and legumes, can frequently be disposed of more profitably when fed to live stock than when sold as grain or hay. Live stock supply food, and in this way they help to reduce the living expenses of the farmer and his family. When live stock are kept, there is work to be done all the year around; a more even distribution of work throughout the year helps to solve the labour problems of the farmer. A good crop rotation is

possible when there are animals to make use of grass and legume crops.

Live stock tend to put farming on a safer, more permanent basis, and therefore they should become one of the main branches of agriculture in Western Canada and not merely a side-line.

DAIRY PRODUCTS

The dairy industry in Western Canada. Dairying is every year becoming more and more important as a source of wealth, and as a factor in reducing the risks of farming and maintaining the fertility of the soil. Explain fully each point made in the foregoing statement. Dairy products from the prairies are now being marketed in British Columbia, Eastern Canada, Great Britain, and other parts of the world. Canadian butter and cheese must be sold in the British and other markets in keen competition with the dairy products of New Zealand, Australia, the Argentine, Denmark, Siberia, and a number of the Central European states. Therefore, if Canada is to secure her share of the dairy business of the world, Canadian dairymen must exercise every precaution to see that their products measure up to the highest standards of quality.

Canada, however, is not always an exporter of butter. At times she has had to import this important dairy product. This fact indicates that the domestic (home) market is of great importance to producers of dairy products, and careful attention should therefore be paid to its requirements.

The constituents of milk. To find the contituents of milk make the following tests.

Exercises

1. Place about 25 c.c. of milk in a beaker, and boil it. Collect the scum that gathers on the top of the milk and remove it to a test-tube by means of a stirring rod. Test the scum for protein as you did the seeds in Exercise 4, page 255. This protein, which is coagulated or thickened by heat, is called albumen.

2. To the portion of milk that remains in Exercise 1, add a few drops of acetic acid or vinegar. Stir it well. When a thick curd

is formed, filter it. Save the *filtrate* (the liquid that passes through the filter paper) for Exercise 3. Test the curd for protein. This protein, which is thickened by an acid, is known as casein.

3. Pour about 2 c.c. of the filtrate obtained in Exercise 2 into a test-tube, and add an equal quantity of Fehling's solution. (See page 256.) Heat it gently. A reddish-brown colour indicates the presence of lactose or milk sugar.

4. Examine a drop of milk or cream under a low-power microscope. Observe the tiny globules of butterfat.

The butterfat in milk is a mixture of several fats. It is the lightest constituent, and is held in suspension in the form of tiny globules from one fifteen-thousandth to one twenty-five-thousandth of an inch in diameter. Besides the constituents indicated in the foregoing experiments, there is in milk, ash or mineral matter, and water. Milk is also rich in vitamins, which are essential to growth and health. Milk is considered to be a perfect food, especially for young animals. Explain the functions which each of the constituents of milk performs in the life process of the animal body. (See page 257.)

Chemical Composition of Milk

Water	87.5 per cent
Fat	3.8 per cent
Casein	2.6 per cent
Albumen	.7 per cent
Sugar	4.7 per cent
Ash	.7 per cent
Total	100.0 per cent

The Babcock test. The Babcock test is used to determine the percentage of butterfat contained in milk, cream, skim-milk, buttermilk, condensed milk, and whey. While the procedure varies slightly in each case, all tests are the same in principle. To test milk, proceed as follows:

(*a*) Thoroughly mix the sample of milk. This is best done with a small quantity by pouring it back and forth from one vessel to another. It is important to bring the milk to a temperature of from 60° to 70° Fahrenheit. (*b*) By means of a 17.6 c.c. pipette,

measure 17.5 c.c. of milk into a test-bottle (.1 c.c. of milk adheres to the sides of the pipette). Suck the milk some distance above the 17.6 c.c. mark on the stem of the pipette, quickly place the finger over the upper end, release the pressure of the finger slightly, and allow the milk to run down to the mark. Holding the bottle on a slant, as shown in Figure 205, insert the end of the pipette, and carefully allow the milk to flow down one side of the neck. (*c*) Fill the acid cylinder to the 17.5 c.c. mark with sulphuric acid (specific gravity 1.82-1.83). If nothing but stronger acid is available, use less. Holding the test-bottle on a slant, carefully pour the acid into the bottle. Turn the bottle slowly around so that the acid washes down any milk in the neck. There should now be two layers in the bottle—the milk above the acid, without much of a dark band between. (*d*) To mix the acid and the milk, hold the bottle by the stem, and gently rotate it until a dark, uniform colour results. Be careful not to splash the contents of the bottle into the neck. Note the heat produced. (*e*) Place the bottle in the tester. Be sure that the machine is balanced. It is a good plan to make at least two tests, so that the bottles can be placed opposite to each other in the centrifuge. Whirl the bottles for five minutes at the speed indicated on the tester. (*f*) Stop the machine, and add hot water to bring the contents of the bottles to the base of the neck. (*g*) Whirl them for three minutes. (*h*) Stop the machine, and add more hot water to float the fat into the necks of the bottles—drop the water this time directly on the fat. (*i*) Whirl the bottles for two minutes. (*j*) Measure the percentage of fat in the milk by means of dividers. Place the lower point of the dividers at the extreme bottom of the butterfat column, and the top point at the extreme top. Drop the dividers until the lower point touches the zero mark; the upper point will indicate the percentage of fat in the sample. (*k*) The bottles should be emptied immediately, washed with hot water and washing soda, then rinsed with clean water.

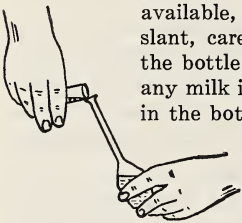

FIG. 205. Diagram showing how to hold the test-bottle when adding acid or milk.

Test-bottles, pipettes, and measuring glasses (except the acid measure) used in connection with the testing of milk and cream should be tested for accuracy by government officials and ineffaceably marked.

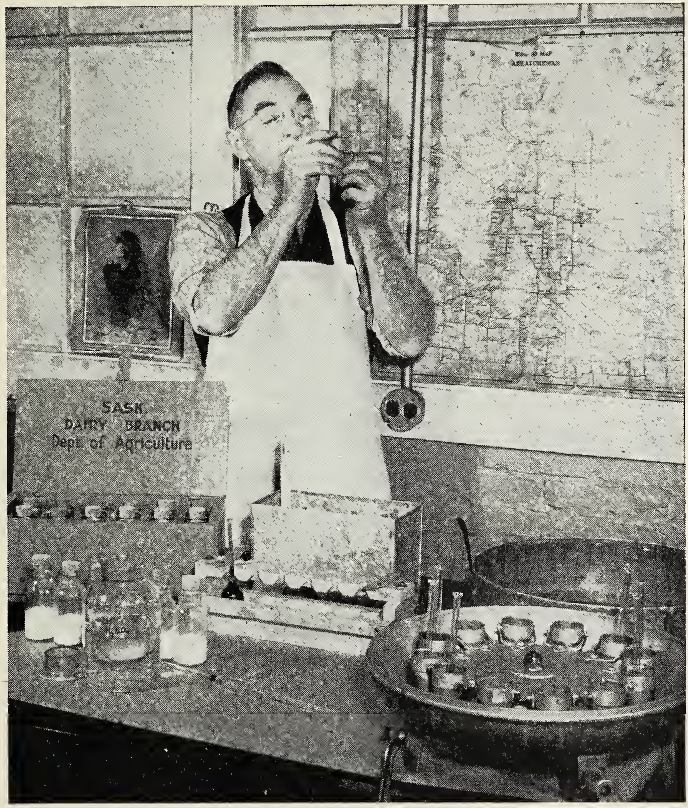

FIG. 206. Measuring the butterfat content of milk by means of the Babcock test. Notice: the bottled samples of milk at the left; the Babcock tester containing several test-bottles at the right (there is another bottle in the wooden rack in the centre); the bottle of sulphuric acid (marked H_2SO_4); the glass pipette near the centre of the table; and at the back of the table a metal container in which there is hot water to keep the contents of the test-bottles warm until the fat is measured. The man in the illustration is using a pair of dividers to measure the length of the butterfat column in the neck of the test-bottle in his hand. While the Babcock test is relatively simple, great care and accuracy are necessary to secure reliable results. (Photo from Saskatchewan Film Board)

NOTE.—Every school should have a copy of Publication No. 611, *The Testing of Milk, Cream, and Dairy By-products*, distributed by the Department of Agriculture, Ottawa. Study this bulletin carefully to avoid mistakes when conducting a Babcock test, and also to learn how to keep the test-bottles clean.

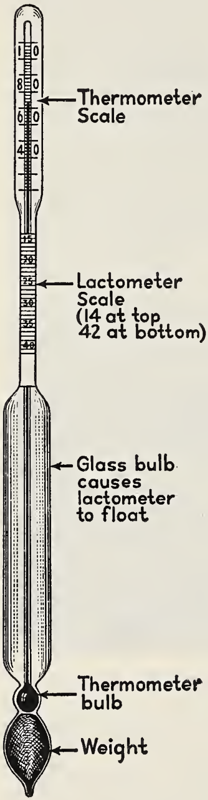

FIG. 207. A combined thermometer and lactometer.

The principles of the Babcock test. (1) The fat is the lightest constituent of the milk. (2) The acid dissolves all the constituents of the milk, except the fat, and increases their specific gravity. (3) The centrifugal force developed by the rapid whirling throws the heavier constituents to the outside of the whirl, and leaves the fat in the centre or at the top of the bottle.

Cream. Cream is produced by collecting the butterfat into a small portion of the milk serum. It may be separated from the other constituents by allowing the milk to stand in pans, either shallow or deep, or by means of the centrifugal cream separator. The separator method leaves less fat in the skim-milk, produces a more uniform quality of cream, and saves time and labour. The parts of the separator that come in contact with the milk should be thoroughly washed and well sterilized each time the machine is used. In either case, the separating should be done as soon as the milk is drawn from the cow. Why?

Specific gravity of milk. The specific gravity of milk is determined by a special type of hydrometer known as a lactometer. The principle upon which the lactometer operates is, that the greater the specific gravity of the milk, the less the lacto-

meter sinks in it, and *vice versa.* The reading should be taken when the milk is at a temperature of 60° Fahrenheit, and the milk should be mixed well before the reading is made. In order to obtain the specific gravity of the milk from the lactometer reading (L.R.), 1000 is added to the L.R. and the result divided by 1000, as:

$$\text{S.G. of milk} = \frac{\text{L.R.} + 1000}{1000}$$

For example, if the lactometer reading at 60° is 31, then

$$\text{S.G. of the milk} = \frac{31 + 1000}{1000} = \frac{1031}{1000} = 1.031$$

The specific gravity of normal milk usually averages about 1.0315.

Solids not fat. Total solids. The total solids (T.S.) in milk are the fat, albumen, casein, sugar, and ash. The solids not fat (S.N.F.) are the foregoing with the exception of the fat.

The percentage of solids not fat in a sample of milk is determined from the percentage of fat and the lactometer reading, as:

$$\%\ \text{S.N.F.} = \frac{\%\ \text{fat} + \text{L.R. at } 60°\text{F.}}{4}$$

The percentage of total solids is obtained by adding the percentage of solids not fat and the percentage of fat.

Adulteration of milk. The adulteration of milk by watering or skimming may be detected by determining the percentage of fat, the lactometer reading, and the percentage of solids not fat.

Watering is indicated by:

1. Low percentage of fat.
2. Low lactometer reading.
3. Low percentage of solids not fat.

(All three factors are reduced in equal proportion by the addition of water to milk.)

Skimming is indicated by:

1. Low percentage of fat.
2. High lactometer reading.
3. Normal or slightly high percentage of solids not fat.

(The lactometer reading is high because of the removal of fat, which is the lightest constituent of milk. The solids not fat are normal or slightly higher because they are not removed by skimming.)

Bacteria in milk. There are many forms of bacteria (see page 189) found in milk. It has been estimated that, under certain conditions, there may be present from 500,000 to 8,000,000 bacteria per cubic centimetre—this would not, of course, be the case in fresh, clean milk. The majority of these micro-organisms are friendly and useful; for example, the lactic acid bacteria, which are responsible for the souring of milk, and which also assist in digestion. The harmful forms are those that cause milk to decay. Under certain conditions, organisms that produce ropy or stringy milk and pathogenic or disease producing bacteria may also be present. State the different sources from which bacteria may enter milk.

Methylene blue reduction test. This test is used in many larger creameries to determine the bacterial quality of milk. The principle of the test is that bacteria react with certain dyes. In the case of methylene blue, the reaction is indicated by a loss of colour. The larger the number of bacteria acting upon the dye, the more quickly the colour disappears.

Method

The milk to be tested should be well stirred. Then 10 c.c. of milk are removed and placed in a glass test-tube about 2 cm. in diameter and 25 c.c. in capacity. One c.c. of methylene blue solution is added, a rubber stopper is inserted in the mouth of the test-tube, and the milk and the dye are mixed by shaking. The colour should then be "robin's egg blue." The test-tube is then placed in a water bath and kept at a temperature just under 100° Fahrenheit until the colour changes. An exact record is kept of the time required for each sample under test to lose its blue colour completely. The following outline indicates the results that may be expected:

1. If the milk is not decolorized in five and a half hours, it contains less than 500,000 bacteria per c.c., and is good milk.
2. If the milk is decolorized in from two to five and a half hours, it contains from 500,000 to 4,000,000 bacteria per c.c., and is fair quality milk.
3. If the milk is decolorized in from twenty minutes to two hours, it contains from 4,000,000 to 20,000,000 bacteria per c.c., and is poor milk.

4. If the milk is decolorized in twenty minutes or less, it contains over 20,000,000 bacteria per c.c., and is very poor milk.

When the test is conducted on a large scale, special equipment such as a 10 c.c. copper dipper for taking milk samples and a 1 c.c. pipette for adding dye, is used, but equipment at hand should serve the purpose in schools. Methylene dye solution is prepared by dissolving one methylene blue tablet in 50 c.c. of boiling water, then diluting to 200 c.c. with cold water. Before making a test, the test-tube, dipper, pipette, or other equipment which comes in contact with the milk should be thoroughly sterilized by immersing in boiling water or steaming for several minutes. After each test, test-tubes should be well washed with hot water and washing soda.

The souring or ripening of milk. The souring or ripening of milk is brought about naturally by the lactic acid bacteria. The bacteria produce a ferment, which breaks down the milk sugar forming lactic acid. The acid thickens and precipitates the casein. The precipitate is known as *curd*, and the liquid that is left is called *whey*.

Exercises

1. Test a sample of sour milk with blue litmus paper. A red colour indicates the presence of an acid.
2. Review Exercise 2, page 290.

Determining the percentage of acidity in milk. The basis of the test to determine the acidity of milk is the fact that alkalis and acids neutralize each other in definite, known proportions. When it has been determined that a certain amount of an alkali has been used to neutralize a quantity of acid, the amount of acid included will be known. The normal acidity of sweet milk ranges from .16 to .20 per cent.

Method

Thoroughly mix the milk to be tested. Place 10 c.c. of milk in a glass tumbler or beaker. (Use a 10 c.c. pipette, if available; if not, carefully pour the milk into a graduate jar until 10 c.c. are measured out.) Rinse the pipette with a few cubic centimetres of distilled water or clean rain water, and add the rinse water to the beaker. Add from 3 to 5 drops of phenolphthalein solution to the milk to act as an indicator. By means of a 10 c.c. burette (see Figure 208)

carefully add alkali solution (caustic soda) to the milk, stirring with a glass rod until a faint pink colour is obtained for a few seconds uniformly through the mixture. The colour should disappear in a few seconds; if it does not, the neutral point has been passed. (If a burette is not available, measure a definite quantity of the alkali solution into a graduate jar, and add it to the milk by means of an eye-dropper, carefully noting the exact amount used.)

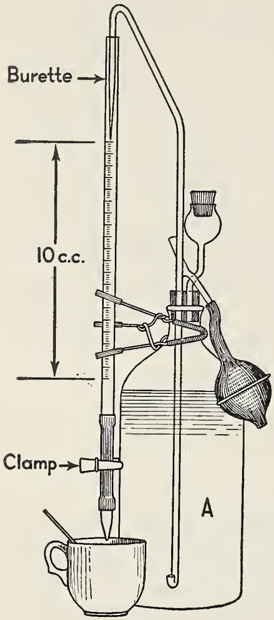

FIG. 208. Type of apparatus usually used to determine the acidity of milk. The alkali solution A is forced into the burette by means of the rubber bulb.

When standard alkali solution (one-ninth normal) is used, 1 c.c. of alkali solution neutralizes .1 per cent of acid in the milk. For example, if 1.90 c.c. of alkali were used, the percentage of acidity in the milk would be 1.90 x .1 = .190.

It would seem that the easiest method of preparing the alkali solution would be to dissolve caustic soda in water in the proportions of $4\frac{4}{9}$ gm. of caustic soda in 1000 c.c. of solution. But this method is not accurate, owing to the difficulty of obtaining caustic soda chemically pure and free from moisture. It would be necessary to keep in mind that the solution would probably be too weak and would not indicate as much acid as was perhaps actually present in a sample of milk. This procedure, however, might be followed by students or teachers when the following correct method is not possible. The correct method of preparing the alkali solution is to obtain a ninth-normal acid solution and make up the alkali solution so that the acid solution and the alkali solution neutralize each other in equal volumes. The alkali solution should be protected from the air, as it quickly weakens by neutralizing carbonic acid in the atmosphere. The phenolphthalein indicator is prepared by dissolving 1 gm. of phenolphthalein in 100 c.c. of 25 per cent alcohol.

NOTE.—The bulletin *The Testing of Milk, Cream, Butter, Cheese, and Dairy By-products*, mentioned on page 294, contains valuable information about testing milk for acidity and bacterial quality.

Exercises

1. In a sample of 10 c.c. of milk to which 1 c.c. of methylene blue dye solution had been added, the blue colour completely disappeared in three hours and twenty minutes. What is indicated in respect to the bacteria content of the milk and the quality or grade?
2. If 2.4 c.c. of alkaline solution were required to neutralize the acid in a sample of 10 c.c. of milk, what was the percentage of acid in the milk?
3. If the lactometer reading of a sample of milk at 60° Fahrenheit is 32, what is the specific gravity of the milk?
4. A sample of milk was found to contain 3.5 per cent fat and to have a lactometer reading of 32. Calculate the percentage of solids not fat and total solids in the milk.
5. Milk suspected of being adulterated was found to have a low percentage of fat, a high lactometer reading, and a normal percentage of solids not fat. What form of dilution, if any, had taken place?

Safeguarding milk by pasteurization. The bacteria or germs causing typhoid fever, diphtheria, tuberculosis, and other diseases find a very favourable growing place in milk, and may be widely spread by this means. They may be destroyed, however, and the milk made safe, by pasteurization. The holding method of pasteurization consists in heating the milk in large vats to a temperature of 145° Fahrenheit, holding it at this temperature for thirty minutes, then quickly cooling it to 50° Fahrenheit, and keeping it at that temperature or lower until it is delivered to the consumer. Another method, known as high temperature, short-time pasteurization, is becoming popular where large quantities of milk are handled. In this case, the milk is heated to not less than 160° Fahrenheit and held for not less than 15 seconds, then cooled to 50° Fahrenheit. (Note.—The foregoing are the temperatures and times specified by the Saskatchewan Department of Public Health.)

Properly pasteurized milk will keep better than other milk, although it should and will sour. When too high a temperature

is used, the lactic acid bacteria are destroyed, and the milk will remain sweet even after it has begun to decay. Distinguish between pasteurizing and boiling.

NOTE.—See *Pasteurization of Milk, Cream, and Dairy By-products*, Publication No. 569, Publications Branch, Department of Agriculture, Ottawa.

Certified milk. Certified milk is high quality milk produced under particularly sanitary conditions and government supervision. It is not pasteurized, but it must have a very low bacterial content. On farms where certified milk is produced, cows are subjected to the tuberculin test semi-annually, to ensure freedom from tuberculosis. The herd is inspected monthly by a qualified veterinary, and employees on the farm are examined monthly by a physician. (Find out whether the production of certified milk is provided for in your province.)

The production and marketing of milk and cream. Milk and cream can be delivered to the consumer in a healthful and wholesome state only when they are produced under conditions which ensure absolute cleanliness, low temperatures, proper care of utensils, etc. To this end, milk and cream are permitted to be offered for human consumption or for sale only when they have been produced under methods and conditions which comply with strict regulations of the Departments of Public Health and Agriculture. The following statements are largely based on these governmental regulations:

Cows must be healthy and free from disease, especially tuberculosis and contagious abortion. They should be well groomed to keep them free from manure and other unclean materials. Just before milking is begun, the flanks and the udders of the cows should be well brushed, and the udders wiped and dried with a clean cloth.

Stables should be constructed to admit a maximum of sunlight. Concrete floors, built to provide good drainage, are desirable. The stables should be kept in a clean condition; no feed or litter

should be moved about the stables immediately before or while the milking is in progress.

Milkers, and all other persons connected with the production and handling of milk, should be cleanly in their habits, and should be free from communicable disease and also from recent exposure to such disease. The Department of Public Health regulations require that "milkers shall, immediately before milking, wash their hands with soap and water and thoroughly dry them. Milking shall be done with dry hands. The milker shall wear a clean overall suit of washable material, used exclusively for the purpose of milking and milk handling."

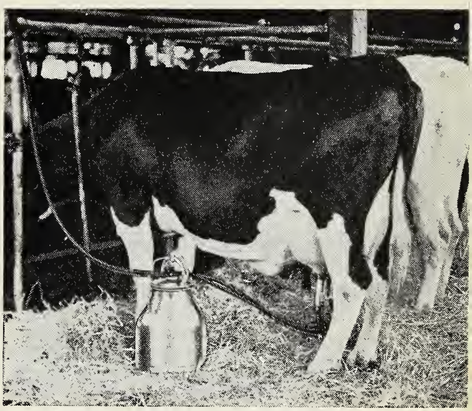

Fig. 209. Cows being milked under ideal conditions. Notice the milking machine, the clean bedding under the cows, and the immaculate appearance of the cows themselves. (Photo from DeLaval Company)

Utensils. Small-topped, seamless pails are best for milking. For shipping purposes, well tinned cans, free from rust, should be used. Rusty or unclean cans may produce undesirable flavours in milk and cream, with consequent lowering of grade and price. Clean utensils are essential; it has been demonstrated that unclean pails, strainers, separator bowls, shipping cans, etc., are responsible for most of the contaminating bacteria which find their way into milk. The following suggestions for cleaning milk utensils are in part from Circular 64, of the Dominion Department of Agriculture: After being used, dairy utensils should be (1) thoroughly washed with cool water, then scrubbed with hot water and washing powder; (2) sterilized by scalding with boiling water (using plenty of water), a chemical sterilizer such as a chlorine compound, or steam under pressure;

Fig. 210. A motor driven cream separator. Notice the spotlessly clean appearance of all pieces of equipment and of the girls who are operating the separator. Cleanliness is the first essential in the production of healthful milk. (Photo from DeLaval Company)

and (3) dried immediately. A film of moisture may be a source of bad contamination. After sterilization, utensils should be placed, inverted, on draining racks in clean, airy places where they are exposed to sun and wind. Dust in the can is less harmful than moisture—if the can becomes dusty, it can be rinsed with boiling water just before milking. Dairy utensils should never be dried with a cloth.

Milk house. As soon as the milk is drawn, it should be removed from the stable, strained, separated, placed in sterilized containers, cooled, and held at a low temperature (50°Fahrenheit by law) until consumed. The milk house should be clean and sanitary, well screened against flies, and separate from or completely partitioned off from the stable or barn.

Delivery and purchase. Milk should be delivered to the consumer in sterilized bottles or other approved containers. In villages, towns, and cities, the sale of milk to individual consumers is usually regulated by special by-laws which provide for the licensing of vendors, the inspection of milk and cream, and other details necessary to ensure healthful products of good quality. Such by-laws must receive the approval of both the Minister of Public Health and the Minister of Agriculture.

The containers of dairy products, except in the case of bulk shipments to distributing centres, shall be "labelled in plainly legible characters" to designate accurately the nature of the contents. Penalties are provided for incorrectly labelling and for adulterating dairy products kept or offered for sale. Milk

bottling and distributing centres are operated under strict government control.

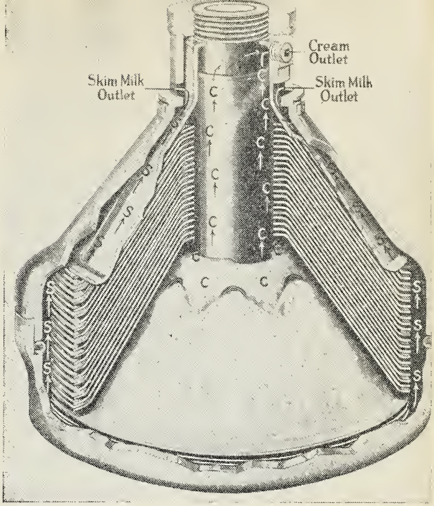

Fig. 211. A section through the bowl of a centrifugal cream separator. By following the letters and the arrows, trace the paths of the cream and the skim-milk as they are separated and made to flow to their respective outlets. The whole milk flows downward through the tubular shaft in the centre of the bowl. When it reaches the discs, it is subjected to centrifugal force. The cream, being lighter, flows toward the centre of the bowl, and the heavier skim-milk moves toward the outside. See also Figure 210. (Photo from Massey Harris Company)

Milk and cream that are shipped to a creamery should go forward in tightly covered cans by the quickest method and should be allowed to stand in the sun only when absolutely unavoidable. Heat encourages the activity of lactic acid bacteria, and sour cream grades lower than sweet. When milk or cream arrives at a creamery, it is weighed and tested, and payment is made according to the number of pounds of butterfat it contains. Creameries are operated under strict government supervision, and must forward to the Dairy Commissioner, at least once a week, a report showing in detail the amount of butterfat purchased daily from each person, the grade, weight, butterfat test, and price per pound of the butterfat, the net price paid and the disposition made of all cream purchased. Samples taken from each shipment for testing purposes must be held under proper conditions until the following day, to be available for checking in case a government inspector happens to visit the plant. Inspectors pay frequent visits to all creameries for the purpose of enforcing the regulations controlling the sale of milk and milk products.

The products. The Department of Public Health gives the standard for wholesome, healthful milk in the following definition:

"Milk is the natural, whole, and fresh product obtained by the complete, uninterrupted milking of one or more healthy cows, excluding that obtained within two weeks before and one week after calving. It shall be free from blood, pus, or disease producing organisms, from disagreeable odour and taste, and from colouring matter, preservative or other chemical, or anything foreign to natural milk. It shall contain not less than 3.25 per cent of milk fat and not less than 11.75 per cent of total milk solids. If milk is mixed for the purpose of standardizing the milk fat content, only fresh, pure, and fluid dairy products shall be so used."

Cream offered for sale must "contain not less than 15 per cent of milk fat and shall be free from any substance foreign to milk." Cream is graded as follows:

Table Cream—sweet, clean flavoured, non-frozen cream, the acidity of which is not more than .20 per cent at the time of grading at the creamery.

Special Grade—clean in flavour, of uniform consistency, and suitable for making Special Grade butter. Its acidity shall not be more than .30 per cent at the time of being graded at the creamery where it is to be made into butter.

First Grade—reasonably clean in flavour, of uniform consistency and suitable for making First Grade butter. Its acidity shall not be more than .60 per cent at the time of being graded at the creamery where it is to be made into butter.

Second Grade—any cream that does not meet with the requirements specified for First Grade, or which is bitter, stale, musty, metallic, or otherwise unclean in flavour, but which is suitable for making into Second Grade butter.

Off Grade—any cream with a very objectionable odour or flavour such as that of kerosene, gasoline, stinkweed, onions, or such other flavour as may render the cream not fit for making into Second Grade butter.

A premium of at least two cents per pound of butterfat above the price of First Grade cream is paid for the Special Grade; and First Grade cream demands a premium of five cents per pound of butterfat above the price of Second Grade cream. The price of Off Grade cream is at least five cents less than the price paid for Second Grade.

Butter-making. The production of good butter begins with the cow. Cleanliness is essential throughout. Care should be exercised to see that cows do not eat stinkweed, turnips, or any other food that will taint the flavour of the cream and later the butter. Cream that tests from thirty to thirty-five per cent butterfat is recommended. It should be kept cool and sweet until enough has been gathered for a churning. When fresh cream is being added to the supply on hand, it must first be cooled, then well stirred into the main lot. To ripen the cream, it is heated to 70° Fahrenheit, until it begins to thicken. It is then cooled to churning temperature and held for several hours. When ready to churn, the cream should have a pleasant taste and smell, and be smooth and free from lumps. Large quantities of butter are now being made from sweet cream, which produces a milder flavoured product.

The temperature of the cream, when put into the churn, should be such as to bring the butter to the size of plump wheat kernels in from thirty to thirty-five minutes. Churning temperature varies a great deal according to the richness of the cream, the season of the year, the length of time the cows have been milking, the breed of cows, and the feed the cows have been receiving. Too high a temperature produces weak-textured butter, and low temperatures bring the butter very slowly. A barrel churn is best. It should be well scalded, then cooled by cold water before being used. Enough cream should be poured through a strainer into the churn to fill it about one-third to one-half. If necessary, colouring material, from one to four drops per pound of butter, is then added. In order to secure proper percussion, the churn should not be turned too rapidly. It is usually necessary to open the gas valve several times to allow the gas that forms to escape. The clearing of the glass in the top of the churn indicates that the churning has "broken." When the butter is about the size of plump wheat kernels, the buttermilk is drawn off, and the butter is washed at least twice with water at a temperature a few degrees lower than the churning tempera-

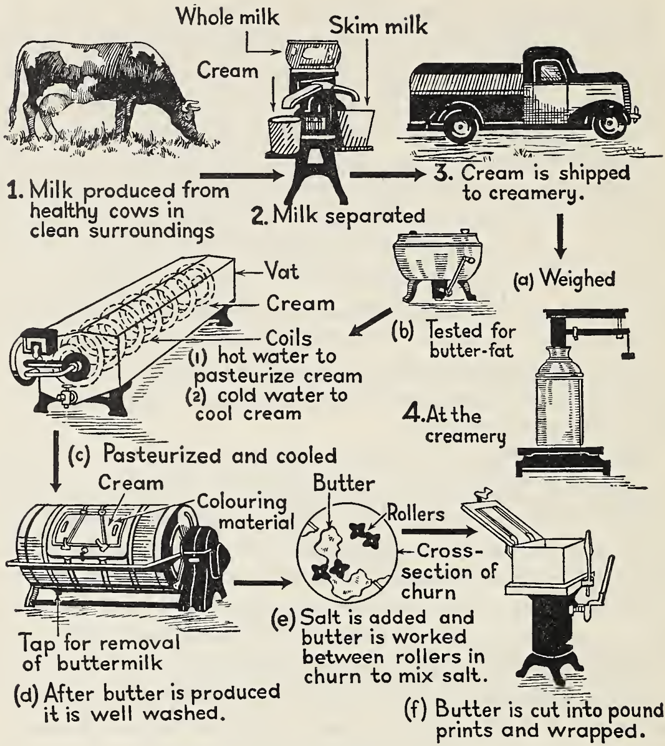

Fig. 212. The story of a pound of butter. Follow the arrows.

ture. Care must be taken to wash out all the buttermilk. Salting is most satisfactorily done in the churn. One-half of the salt is sprinkled over the butter and mixed by tilting the churn back and forth. The balance of the salt is then added, and the churn is revolved several times. Salt, when it is added at the rate of from one-half to one ounce per pound of butter, will improve the flavour and keeping quality, and will expel excess moisture.

After the salt is thoroughly mixed into it, the butter is removed from the churn to the worker. Working should be done only to squeeze out the water and further mix the salt. Slicing or rubbing with the worker should be avoided—a pressing motion only is required. Over-working produces a broken-grained, greasy butter. When the working is complete, the butter is packed into clean crocks or in pound prints. In each case it should be wrapped in parchment paper. An attractive cardboard carton for each print is desirable. Every package of butter must, by law, show on it the maker's name and the kind of butter.

Dairy versus creamery butter. Dairy butter is legally defined as butter that is manufactured in a dairy, which is "a place where the milk or cream of less than fifty cows is manufactured into butter." Creamery butter is butter that is manufactured in a creamery, which is "a place where the milk or cream of more than fifty cows is manufactured into butter."

Dairy butter is largely a product of the farm. It is quite possible for a farmer or other person making dairy butter on a small scale to produce butter of good quality. Unfortunately, much poor dairy butter finds its way to market. Usually creamery butter is superior to dairy butter, for the following reasons: Creameries must be registered at the office of the Dairy and Cold Storage Commissioner, Ottawa. They operate under strict government supervision and inspection. They pasteurize all the cream that is used in their butter. Creamery butter is made to conform to exact standards of colour, saltiness, flavour, etc. When ready for market, creamery butter is graded, on the basis of a specific scale of points, in respect to flavour, texture, incorporation of moisture, colour, salting, and boxing and packing. Since the production of creamery butter is so strictly regulated, it stands to reason that the product is generally more dependable than dairy butter. As a result the production of dairy butter has been steadily declining in all parts of Canada in recent years.

Butter offered for sale must not contain over sixteen per cent water or less than eighty per cent milk fat. Adulteration of

butter is prohibited, as are also the manufacture, importation, and sale of butter substitutes in some parts of the Dominion. Butter for sale must not be "rechurned" or "renovated." Prints, blocks, squares, or pats of butter must be the full net weight of one-quarter, one-half, one, or two pounds, but farmers may sell rolls or lumps of butter of indiscriminate weight. Packages, boxes, cartons, etc., must be labelled or branded in good-sized, legible, indelible letters to designate exactly the nature and grade of the contents, and the province and creamery or factory in which the butter was manufactured.

Exercises

1. See page 363 for suggestions on the marketing of butter. Is there a butter pool or a co-operative creamery in your district? What are the advantages of these organizations? Compare creamery and dairy butter.
2. Outline a plan that would enable a group of farmers to establish a reputation for good butter. (See page 364.)
3. What quantity of butter can be made from 500 pounds of cream testing thirty-five per cent butterfat? One pound of butterfat will produce one and a quarter pounds of butter. What materials become mixed with the fat to make the additional quarter-pound?

NOTE.—An excellent, well illustrated reference on butter-making is *Butter-making on the Farm,* Publication No. 603, free, from the Publicity and Extension Branch, Department of Agriculture, Ottawa.

The production of cheese. Cheese is manufactured from the casein of milk. Rennet, an extract from calves' stomachs, is used to ripen the milk and separate the casein (curd) from the other constituents. When the curd is firm, the whey is strained off, and the curd may be salted and used fresh as cottage cheese. To make hard or Cheddar cheese, a firmer curd is produced. It is cut up into small cubes, and the whey is removed, after which the curd is salted and packed into moulds or presses, where it is held until all of the free whey has been squeezed out. Finally, it is held at a low temperature for several weeks to ripen or cure. During the ripening process, certain forms of bacteria become

active and impart the flavour to the cheese. By inoculating newly made cheese with special bacteria, different kinds of cheese may be produced. Cheddar is the standard Canadian cheese, and is the kind that is exported to Great Britain. What are other markets for Canadian cheese?

Cheese, like butter, must not contain "any fat or oil other than that of milk or cream." No preservative may be incorporated other than common salt. Cheese is graded, according to a specific scale of points, in respect to flavour, texture, closeness, colour, finish (size and shape), and boxing and marking. Each cheese must be branded to designate type, grade, and place of manufacture. Cheese factories are required to be registered at the office of the Dairy and Cold Storage Commissioner, Ottawa.

Cheese of high quality can be made only from milk of good quality. Farmers shipping milk to a cheese factory should exercise every precaution to ensure their shipments arriving in the best possible condition.

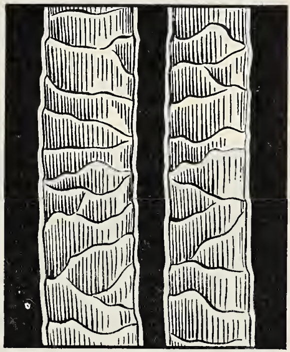

Fig. 213. Wool fibre as seen through a microscope.

CO-OPERATIVE GRADING AND MARKETING OF WOOL

Wool fibre is covered with minute scales, which impart strength and lustre to the wool, and which interlock when the fibres are woven into cloth. Some breeds of sheep produce finer wool than others. The finest wool is from sheep of Merino breeding. In Canada, the annual wool crop is now almost 20,000,000 pounds. Some 5,000,000 pounds are used on the farms for spinning, principally in the province of Quebec.

The great bulk of the wool crop of the western provinces is now marketed co-operatively by the Canadian Co-operative Wool Growers, Limited. The members of this association send

FIG. 214. Canadian Co-operative Wool Growers' warehouse at Weston, Ontario. (Photo from Canadian Co-operative Wool Growers)

FIG. 215. Grading wool at the warehouse shown above. (Photo from Canadian Co-operative Wool Growers)

their wool to Lethbridge, Calgary, Edmonton, Saskatoon, Moose Jaw, Regina, Winnipeg, and other centres conveniently located for assembling carload lots. It is then shipped to Weston and Carleton Place, Ontario, where it is graded by the company. The graded wool is inspected by Dominion Government Inspectors.

Other leading grading centres have been established at Lennoxville, Quebec; at New Westminster, British Columbia; and at points in Nova Scotia and Prince Edward Island. The Canadian Co-operative Wool Growers have agents in Boston and in London, and the wool handled by this organization is marketed in Canada, the United States, and Great Britain.

Wool is graded primarily according to the length and the fineness of the fibre. There are two main grades; *staple*, or wool over two inches long; and *clothing*, or wool less than two inches in length. These grades are subdivided according to fineness as, fine, fine medium, medium, low medium, and low. Lower grades are known as coarse and lustre, and there are grades for wool that is seedy, burry, wrapped with binder twine, or otherwise inferior or damaged. Further sub-grades are necessary, particularly for wools from Western Canada; these are known as bright, semi-bright, and dark, and are based on colour, quality, and general condition. All Canadian wool is also classified into three broad groups which correspond to broad geographical areas. Wool from Ontario, Quebec, and the Maritime Provinces is known as "eastern domestic." Western Canada wool is classified as "western domestic" and "range." The latter is from the ranches of southern Saskatchewan and Alberta and central British Columbia, and includes the finest wools produced in Canada, since the flocks from these sections have Merino blood. The upper part of a wool grading statement is reproduced on page 312 to indicate more clearly the various classifications.

It is important to market wool in as good condition as possible. To do this, the following precautions should be observed: Sheep should be kept away from places from which seeds, straw, and chaff may find their way into the wool. Pastures in which there

Folio..............

WOOL GRADING STATEMENT

LIVE STOCK BRANCH, OTTAWA

Co..............

PROV..ASS'N..........................SHIPPER'S LOT NO..............

WESTERN DOMESTIC ☐ WESTERN RANGE ☐ EASTERN DOMESTIC ☐

Member's name..Address......................................

Weight Railroad Bill of Lading..No. of Sacks.........Condition of Sacks..............

Gross Weight at Grading...Tare................Net Weight...................

Grade	Corresponding English Counts		Bright		Semi-Bright		Dark		Revenue
			Lbs.	Price	Lbs.	Price	Lbs.	Price	
Fine Staple / Fine Clothing	64's-70's-84's	Standard Grades							
Fine Med. Staple / Fine Med. Clothing	58's-60's								
Medium Staple / Medium Clothing	56's								
Low Med. Staple / Low Med. Clothing	48's-50's								
Low Staple / Low Clothing	44's-46's								
Lustre / Coarse	40's-44's								
Gray and Black,—Fine / Medium									

are burs should be avoided. Shearing should be done reasonably early, and care should be taken to keep the fleeces clean and free from foreign material. In general, fleeces are rolled and tied intact as they are shorn. Before it is rolled up each fleece should be shaken to remove at least part of the seeds and chaff which may be in it. Straws should be picked off. Fleeces should be rolled tightly and tied with approved paper fleece twine to make an attractive roll. The wool should then be packed in special wool sacks, and stored in a cool, dry place until it is shipped. If groups of sheep-owners arrange for pool cars, shipping costs will be reduced. There are advantages, too, in consigning wool for official grading and sale by grade, rather than disposing of it to local dealers; usually better prices are secured, and there is an incentive to produce higher quality fleeces, which is beneficial to the market as well as to the individual grower.

Exercises and Problems

1. Two animals were auctioned at the same sale. In conformation, colour, markings, and condition, there was little to choose between them. Both were pure-bred, and both had pedigrees. One sold for $2500, and the other for $250. Account for the great difference in the price of these animals.
2. Two cows each produce 6000 pounds of milk per year. One cow's milk tests 3.6 per cent, and the other 4.8 per cent. How much butterfat does each produce? Which is the more profitable cow if butterfat is worth 35 cents per pound? Has the skim-milk any value?
3. Try to arrange at least one of the following excursions: (*a*) to a creamery to observe methods of receiving, weighing, sampling, testing, pasteurizing, churning, etc.; (*b*) to a cheese factory; (*c*) to a place where sheep-shearing is being carried on.
4. Prepare a discussion on the value of high quality in the products dealt with in this chapter. Be ready also to outline means which will enable live stock owners to secure the highest prices for their products.
5. "Cleanliness is the foundation of good dairying." Discuss this statement from the standpoint of (*a*) the influence the manner of handling milk in the initial stages of production has upon the final

product; (*b*) profitable dairying, and (*c*) the value of the product to the consumer.

6. Explain fully the importance of efficient control of bacterial action in the production of milk, cream, butter, and cheese.

7. What precautions have governmental departments taken to ensure healthful dairy products?

8. A special grade of milk retails at 20 cents per quart, and has a guaranteed butterfat content of 5 per cent. The regular grade of milk sells for 13 cents per quart, and has a butterfat content of 3.5 per cent. In which case does the consumer receive the most butterfat for his money?

9. A certain creamery sells a special grade of milk with a butterfat content of 15 per cent, the price being 26 cents per quart. Does the consumer receive more butterfat for his money in this case than in the previous exercise? In which case does he receive more protein and mineral matter?

10. Outline the methods employed in the marketing and grading of the wool handled each year by the Canadian Co-operative Wool Growers, Limited.

CHAPTER 14

FARM ANIMALS (Continued)—POULTRY

CLASSES, BREEDS, VARIETIES, TYPES

A generation ago, the keeping of poultry on the average Canadian farm was a very minor side-line; special hen houses were uncommon, and scientific breeding, feeding, and management were in the elementary stage. Today it has become a major industry in many areas. Interest in and knowledge of poultry-keeping has spread rapidly; markets have also expanded, and the importance of foreign markets for both eggs and poultry has increased markedly.

Classes, breeds, varieties, and types of chickens. Chickens are grouped into classes according to place of origin. The classes are divided into breeds on a basis of ancestry, and the breeds are further divided into varieties according to the colour of the plumage and the kind of comb (single or rose).

Type as applied to chickens indicates their suitability for a certain purpose. There are the meat type, the general-purpose or utility type, the egg type, and the game type. Practically no breed is bred for meat production alone, so that a strictly meat type breed of chicken is hard to find. Such breeds as the

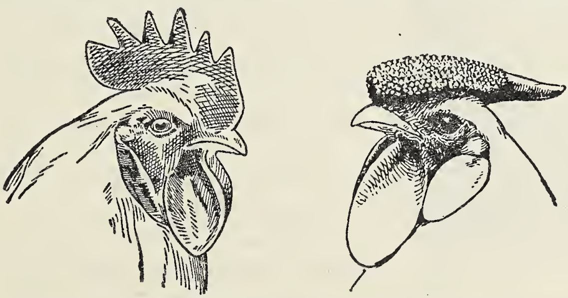

Fig. 216. On the left, a single comb, on the right, a rose comb.

Leghorns are primarily egg type birds and are not suitable for table purposes except as broilers. There are also a number of general purpose breeds, such as the Plymouth Rocks, Wyandottes, Rhode Island Reds, Orpingtons, and others, which produce a plump carcass as well as a good number of eggs.

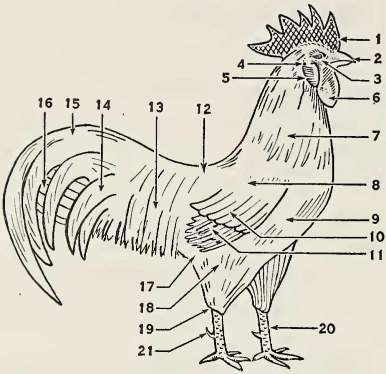

FIG. 217. The points of a chicken: (1) comb; (2) beak; (3) face; (4) ear; (5) ear lobe; (6) wattle; (7) hackle; (8) shoulder; (9) breast; (10) wing-bar; (11) primary wing feathers; (12) back; (13) saddle feathers; (14) tail coverts; (15) sickles; (16) main tail feathers; (17) fluff; (18) thigh; (19) hock; (20) shank; (21) spurs.

The characteristics of a profitable general purpose fowl are: short broad head, clear bright eye, deep wide body, legs short and well set apart, breast bone straight and well covered. There must be a degree of quality about the bird as indicated by the scales of the leg and the alert, fine cut appearance of the head.

The American breeds. The Plymouth Rocks are one of the best known and most popular general purpose breeds. They have single combs, red ear lobes, and yellow legs, and are bred in barred, white, buff, partridge, and other varieties. The "Barred Rocks" are the most common. These birds are hardy, quick maturing, and are good meat producers; many have high egg records.

The Wyandottes have a rose comb, yellow legs, and red ear lobes. The most common variety is white, but some are silver and golden laced. The Wyandottes are very round or ball-shaped birds, are early maturing, and good layers.

The Rhode Island Reds are dark reddish in colour. They have rose or single combs, red ear lobes, yellow or reddish horn-coloured legs, and an oblong, straight-backed body. The

"Reds" are a good table fowl; they are a little slow in maturing, but lay well.

New Hampshires are single combed, with red plumage of a lighter shade than the colour of the Rhode Island Reds. Their bodies are less rectangular in shape. The chicks feather quickly and rapidly reach the egg-laying stage. They are good producers of large eggs, and thus are increasing in popularity.

These breeds, as well as those discussed later, have been developed by crossing and selection. Unless breeding stock is constantly and carefully selected, it tends to revert to the original types and thus to deteriorate in quality and usefulness.

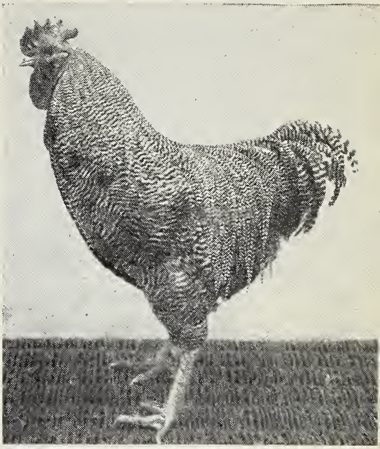

Fig 218. A Barred Plymouth Rock rooster.*

The Asiatic breeds. The Brahmas and the Langshans are the most popular of the Asiatic breeds. Both are large and heavily feathered. In these breeds, strains have been developed with fair egg records and, although they are not recommended for the farm, under certain conditions they give good results. For example, Light Brahmas crossed with Barred Plymouth Rocks make good roasters.

Fig. 219. A White Wyandotte rooster.*

The Mediterranean breeds. The Leghorns are one of the oldest and the best known of the breeds of this class, originating on the north shore of the Mediterranean Sea. They are essentially egg producers, generally surpassing every other breed in this respect, and are found on all large poultry farms where eggs are

*Illustrations from Poultry Division, Experimental Farms Service, Ottawa.

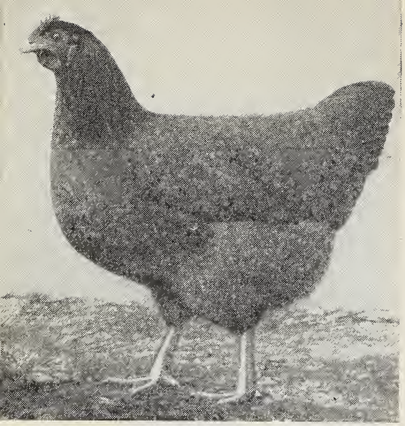

Fig. 220. A Rhode Island Red hen. (Courtesy of *Poultry Tribune*)

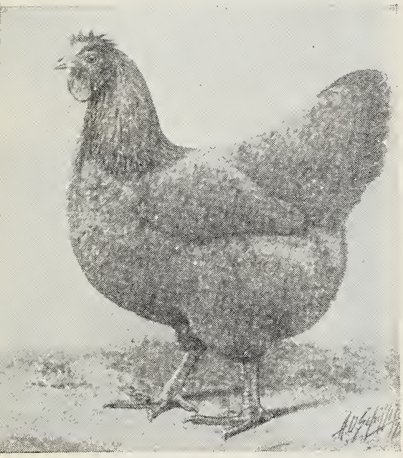

Fig. 221. A New Hampshire hen. (Courtesy of *Poultry Tribune*)

the chief product. They are smaller than the utility hens, more slender in body and usually very active. In colour they may be white, brown, buff, or black. They have single or rose combs, white ear lobes, and yellow legs. The single comb, white variety seems to be the most popular. Leghorns are hardy, and, because of their quick maturing qualities, the young males are valuable for broiler production.

The English breeds. The Light Sussex are good-sized birds with white plumage except as follows: neck feathers black with edging of white; wing tips, dark; tail, main part black; lesser coverts are black edged with white. The Light Sussex are increasing in popularity. Their strong point is their white skin, a good market quality.

The Orpingtons are usually buff or white. They have black or white legs, single combs, and red ear lobes. They are the heaviest of the utility breeds, hardy, slow maturing, and good layers.

The Cornish were developed for fighting purposes. They are poor egg producers, but their great muscular development makes them very suitable for table purposes.

Types and breeds of other farm poultry. Ducks. There are two common breeds of ducks. The Pekins are white, wide, deep, and long of body, early maturing, and in all respects good farm fowl. The Rouens originated in France, and resemble a wild duck in colour.

FIG. 222. A White Leghorn rooster. (Courtesy of *Poultry Tribune*)

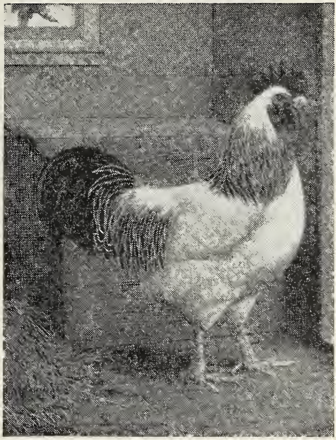

FIG. 223. A Light Sussex rooster. (Courtesy of *Poultry Tribune*)

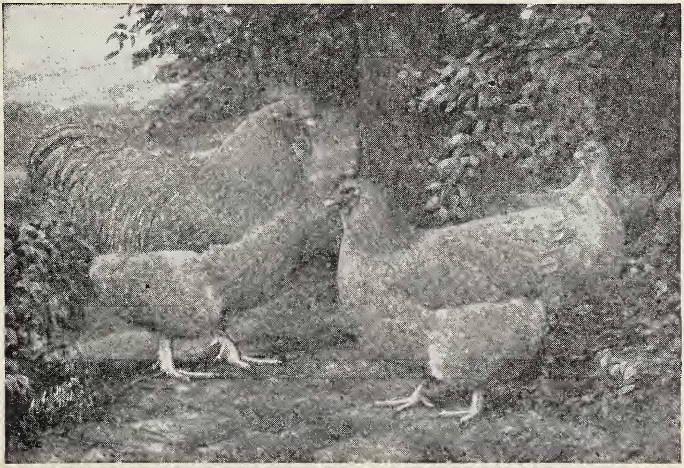

FIG. 224. Buff Orpington chickens. (Courtesy of *Poultry Tribune*)

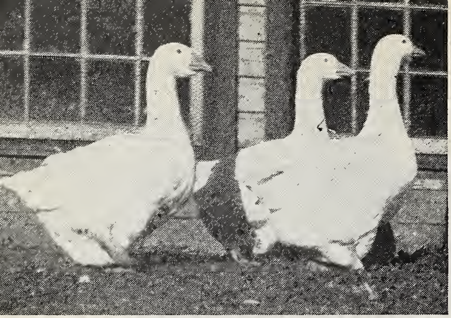

Fig. 225. Embden geese. (Photo from National Film Board)

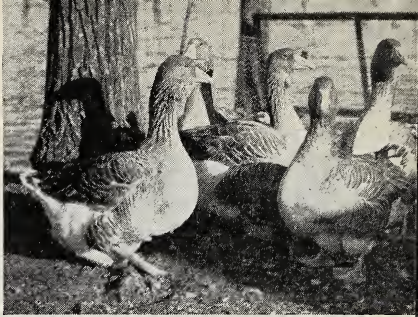

Fig. 226. Toulouse geese. (Photo from National Film Board)

Geese. The gray Toulouse and the white Embdens are the two most common breeds of geese.

Ducks and geese are raised almost entirely for meat. Size and weight, length, depth, and width of body, early maturity, and quality are the desired characteristics of good birds.

Turkeys. The turkey industry now has a place of importance in the Prairie Provinces; and more turkeys are being marketed every year. The most popular and largest breed is the Bronze, named for its colour. The White Hollands are slightly smaller, and are less common. The Narragansett turkeys are moderately large. They are steel-gray in colour, with white barring on wings and tail. Bourbon Reds have become more popular in recent years, due largely to the fact that they are quick maturing and have fine quality as market birds. Turkeys should be large in frame and deep in body.

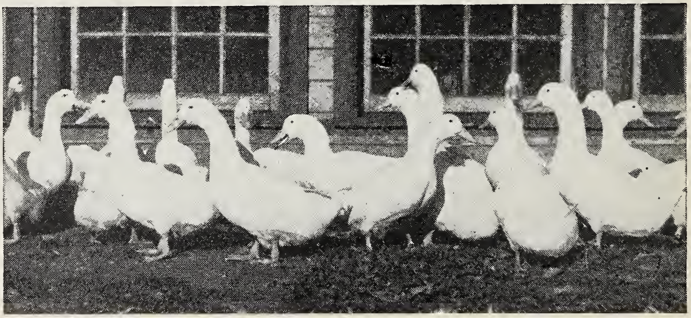

Fig. 227. Pekin ducks. (Photo from National Film Board)

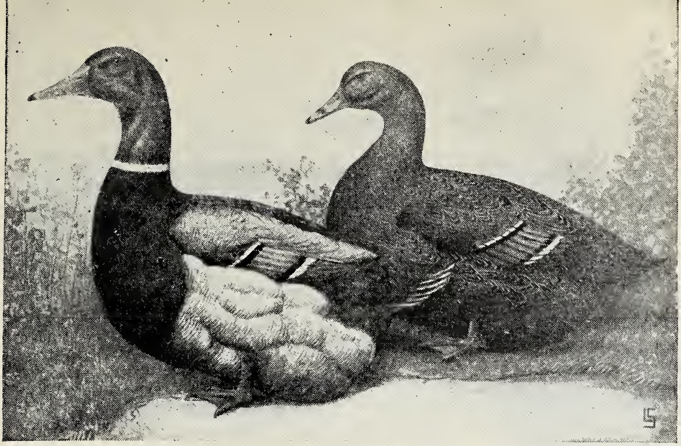

Fig. 228. Rouen Ducks. (Courtesy of *Poultry Tribune*)

THE HOUSING OF POULTRY

The chief considerations in housing poultry are: adequate lighting, good ventilation, dryness, freedom from draughts, convenience, and low cost. Poultry should not be kept in a warm house; a cool place with plenty of fresh air gives best results. Square buildings rather than long, narrow structures, are preferred. There should be plenty of room for scratching and exercise. Each hen requires on the average about four square feet of floor space. But, when the size of the flock is increased to five hundred or more, the average floor space per bird may be reduced to a minimum of two and a half square feet. An area of 20 feet × 20 feet will accommodate one hundred hens.

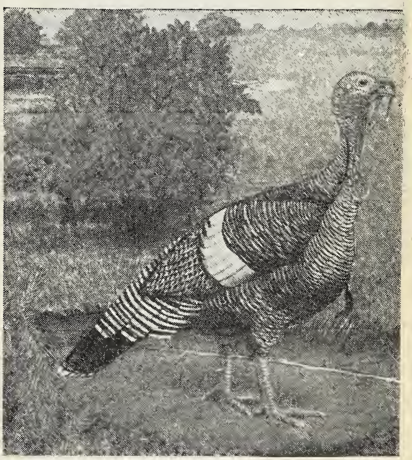

Fig. 229 A Narragansett turkey. (Courtesy of *Poultry Tribune*)

Several methods of ventilation are satisfactory. In one method, half the window space should be glass and the other half factory cotton, arranged in alternate sections. Provision should be made for the opening of at least half the windows during the summer months. A

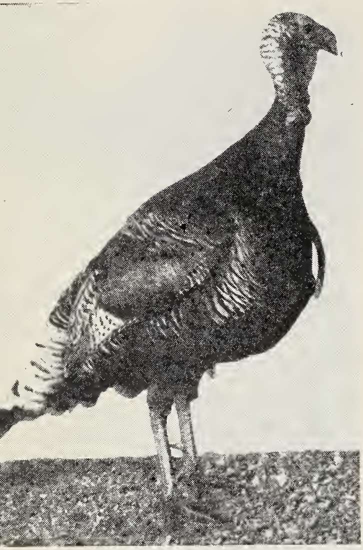

FIG. 230. A Bronze turkey. (Photo from National Film Board)

second system of ventilation depends upon a flue outlet, but requires more careful adjustment. One square foot of window to every fifteen square feet of floor space will supply the necessary amount of light. The windows should be in the front of the house which is best facing the south. A straw loft will provide for a good circulation of air and will absorb moisture. The walls and ceiling should be well insulated, using shavings or commercial insulating material.

Concrete floors are recommended since they are sanitary and afford protection against rats, etc. They should be insulated from the underlying ground by about six inches of gravel or cinders, and kept well covered with a deep layer of clean litter. Floors of earth and wood are also satisfactory under certain conditions. Roosts should be built at the back and north of the house. Each bird will require seven to nine inches of roosting space, depending upon the breed. Dropping boards beneath the roosts will help greatly to keep the scratch litter and the hens clean. A newer plan is to eliminate the dropping boards and construct a pit below the roosts. This may be done by boarding off the space below the roosts and covering the area with wire netting to keep out the hens.

Drinking pans, feed containers, and grit and oyster shell boxes may be placed on the floor or along the walls. Nests of the community type have proven to be very satisfactory. A nest 54 inches $\times$ 24 inches will provide nesting space for fifty hens. The compartment should be kept filled to a depth of six inches with shavings or sawdust.

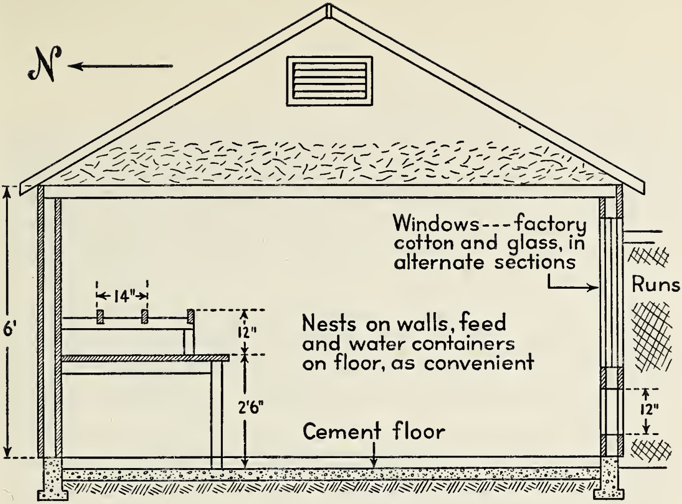

FIG. 231. A plan of a poultry house. How are good conditions of ventilation, temperature, and humidity maintained?

If roosts and nests are built in sections, they can be removed from the house from time to time, washed, disinfected, and aired. The house should always be kept clean; and if possible the interior should be whitewashed frequently. Once a week the house should be thoroughly sprayed with a disinfectant, such as a teaspoonful of creoline in a pint of coal oil. The equipment, too, should be frequently cleaned and disinfected.

NOTE.—Write to your provincial Department of Agriculture, experimental farm, or university for information about approved poultry houses.

POULTRY NUTRITION AND MANAGEMENT

The proper feeding of poultry requires a knowledge of the fowl's requirements and the constituents and suitability of the various grains and other feeds available for use.

In planning rations for poultry, it is necessary to keep in mind that a fowl grows rapidly, matures early, and has a comparatively short life; that it has a high body temperature (106°—107°F.) and rapid respiration, circulation, and digestion; and that it has a short intestinal tract, no teeth, a crop for storage, and a gizzard

for grinding. It therefore requires a concentrated diet. Rations must be low in crude fibre and, especially for laying hens and young chicks, high in protein and mineral matter. Large quantities of water are required. The vitamin content of poultry feeds is also important—rations deficient in vitamins A, B, D, and E lead to deficiency diseases.

Wheat, oats, and barley constitute the greater part of poultry rations. These grains, however, lack sufficient protein and mineral matter to meet the requirements of growth and egg production; and therefore, concentrated supplements, such as meat meal, should be added to growing and laying rations to bring the protein and mineral content to the required level. Proper feeding develops healthy, vigorous birds and ensures greater resistance to disease.

Care and feeding of laying hens. The needs of the laying hen are entirely different from the requirements of poultry that are being fattened. During the summer, when hens are on free range on the farm, they practically balance their own ration. What is a balanced ration? When the weather makes it necessary to shut them indoors, feeds similar to those that they pick up for themselves during the summer months should be provided. Variety is necessary.

Part of the ration for laying hens is provided in the form of whole or cracked grain, called scratch feed, and part in a ground or fine state, called mash or mash mixture. In general, the daily allowance consists of approximately equal parts by weight of scratch grain and mash. The proportions will vary with the time of year, the maturity of the birds, and the rate of egg production.

The scratch feed may consist of equal parts of wheat, oats, and barley, and may be scattered in the litter on the floor of the poultry house twice a day (one-third in the morning and two-thirds in the evening) at the rate of a handful for every two birds —or from twelve to fifteen pounds per hundred birds. Why feed the scratch grain in the litter?

The mash mixtures for various purposes are compounded from a basic formula, the constituents varying in kind and amount according to the requirements of the birds being fed. The mash should include:

Grain or grain products (60-80 per cent)—two or more of wheat, oats, barley, bran, shorts.

Protein supplements (10-15 per cent)—two or more of meat scrap or meat meal, fish meal, liquid or dried milk (especially valuable for chicks or breeding stock), soy-bean meal, or oil cake.

Green feed (0-10 per cent)—in the summer, an alfalfa, clover, or grass range is ideal; when birds are shut-in, dried or fresh alfalfa, lawn clippings, sprouted oats, cabbage, mangels or turnips. Growing chicks and laying hens particularly require green feed.

Minerals (2-4 per cent)—because of shell production requirements, hens require mineral matter such as is available in powdered limestone, bone meal, common salt, fish and meat scrap. Grit is also needed to help with the grinding of food in the gizzard.

Vitamins (0-1½ per cent)—available in fish oil, green feed, liquid and dried milk.

At noon a moist mash may be fed. This may consist of the dry mash, moistened to a crumbly consistency with warm milk or water. The addition of table scraps and boiled potato peelings is good. During the period from November 1st to May 1st, one-half cupful of cod-liver oil per one hundred hens may be included in the moist mash. Feed as much moist mash as the birds will eat in from fifteen to twenty minutes. The mash should be before the hens in hoppers at all times.

Drinking water must always be available. Skim-milk or buttermilk should be supplied if possible.

Fresh air without draughts, exercise, cleanliness, and dryness are essential; good sanitation is important to keep disease in check. When days are less than twelve hours long, lighting the poultry house by means of electric light from 7 a.m. to daylight

and from dusk to 10.30 p.m. has been found to encourage greater egg production and thus to increase the profits from hens during the winter months. A sixty-watt lamp for two hundred square feet of floor space is recommended.

Fattening chickens. Consumers of poultry products demand high quality. Thus, there are very definite advantages in properly fattening poultry before offering them for sale. The advantages of fattening are as follows: (1) There is a higher percentage of tender, well flavoured meat on a fattened bird than on an unfattened one. (2) Gains made during the fattening period increase the total weight of the bird. (3) Fattening raises the carcass to a higher grade. (4) High grades ensure higher prices and greater profits for the producer and better value for the consumer.

Chickens can be fattened while confined in pens, but better quality and finish result when the birds are fattened in slatted crates. The process should begin in the late summer or early fall, when the poultry are from four to five months old. Pens and crates should be kept as clean as possible; and the birds should be dusted with insect powder.

Wheat, oats, and barley will produce good gains when fed either alone or in combination. All grain should be ground as finely as possible; and if oats and barley are of low grade, the hulls should be sifted out. For crate fattening, the practice is to use a mash of grain mixed with skim-milk, buttermilk, or water, mixed to a consistency that will just pour nicely. Birds should be fed lightly at first, then given all they will eat in twenty to thirty minutes twice a day.

Flock improvement. Culling out the poor layers. The profitable hen lays heavily during the winter, when eggs are high priced. Though the proper feeding of a flock is essential, a balanced ration alone will not ensure a high egg-laying record; the hens composing the flock should be of the right type and breeding.

Approved Flock Service. In Saskatchewan, and other provinces, the provincial Department of Agriculture promotes a

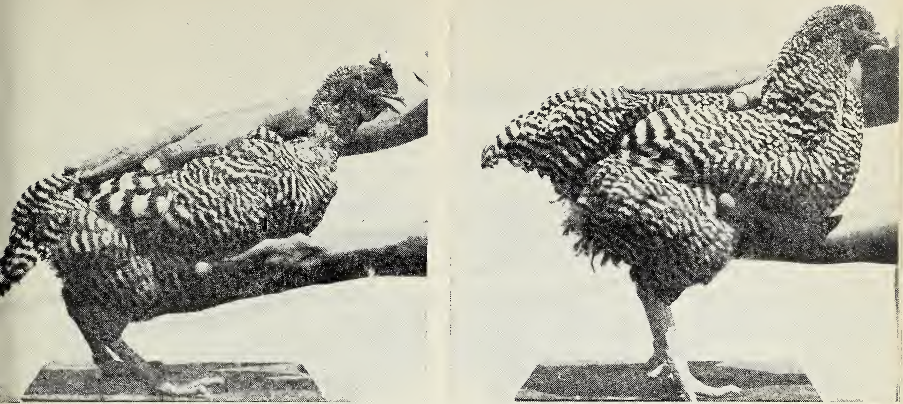

FIG. 232. The hen at the left has a very shallow body and will be a poor layer. The hen at the right has a body of good depth and capacity. She should be a profitable layer. (Photos from Poultry Department, Kansas State College)

breeding programme designed to improve farm flocks and to increase the production of high quality poultry products. The programme provides for an annual fall inspection of poultry flocks, and emphasizes the careful selection of females and the use of high grade males in the flocks under supervision. Flocks which conform to the approved high standards are listed in the Approved Poultry Flock list. To qualify for the "Approved" list, a flock must fulfil the following requirements: It must contain at least seventy-five females which at the time of inspection are eligible to be marked by special sealed leg bands as individuals of high quality, free from standard breed disqualifications, of good physical vigour, and of one variety only. Birds must be free from evidence of disease; they must pass one official clean test for pullorum disease (see page 331) in the current testing season. All reacters must be removed and killed immediately. Rejected birds (below the standard) must be removed from the flock within fourteen days. Only approved, banded females may be mated. Male birds must conform to the approved high standards with respect to breed characteristics, health, R.O.P. certificates (see following section), etc. Feeding, the poultry house, the sanitary condition of the yards and the house, the periodic disinfection of the premises and the equipment, the rotation of poultry yards with a cultivated crop as a safeguard against the contamination

of the soil by germs of poultry diseases, must all conform to the approved methods and standards.

Only poultrymen whose flocks have been approved under this programme are permitted to supply eggs to commercial hatcheries for the production of baby chicks.

NOTE.—Poultrymen and others interested in Approved Flock Service, blood testing for pullorum disease, etc., should write to the provincial Department of Agriculture for fuller information regarding fees and requirements.

Canada Accredited Flocks. An approved flock may qualify as a Canada Accredited Flock when it is established that it is free from pullorum disease and other poultry diseases. Such flocks are subject to unannounced inspections throughout the season.

Record of Performance (R.O.P.) certificates. Pure-bred poultry, of standard variety and free from standard disqualifications, may be entered for Record of Performance certificates. Flocks thus entered are trap nested on the owner's premises. The trap nest holds each hen after laying until the poultry man is able to record her leg band number. Weekly records of the number and the weight of the eggs laid must be forwarded to the Poultry Services, Department of Agriculture, Ottawa. This Department directs the Record of Performance work in the Dominion. At the conclusion of the record period, the owner must take an affidavit that the weekly statement and other required records are correct. Trap nesting requires a good deal of time and is not recommended for the average farmer or poultryman.

Record of Performance certificates may be issued to all birds that in 365 consecutive days lay two hundred eggs averaging at least twenty-four ounces per dozen in weight. On the certificate shall also be noted such additional characters of economic worth as the shape of the egg, the texture of the shell, the market meat type, the weight of the bird for its age, etc.

Cockerels from pens of qualified R.O.P. hens bred to R.O.P. approved males may, by authority of the Dominion Department of Agriculture, be banded and known as "R.O.P. Cockerels,"

provided certain other regulations set forth by the department are also complied with.

Culling for egg production. A good deal can be learned about the egg-laying ability of a flock of hens by handling them, one at a time, to determine body conformation and other physical characteristics closely associated with egg production. An inherited tendency to lay is also important, but, of course, cannot be determined by a physical examination. Good layers are active, healthy, and sound in body.

The following is a comparison of the characteristics of good and poor layers:

CULLING CHART

Good layers have		Poor layers have	Good layers have		Poor layers have
fine lean clean cut medium depth & length	Head	coarse fat wrinkled long narrow	wide long level	Back	narrow short tapering
bright full bulging large oval	Eye	dull shrunken flat small round	large deep soft, pliable thin skin	Abdomen	small shallow hard, fat thick skin
faded	Eye ring	yellow	far apart thin flexible	Pelvic bones	close together thick rigid
pale short stout	Beak	yellow long thin	thin soft loose	Skin	thick coarse, dry tight
white	Ear lobe	yellow	moist large white dilated	Vent	dry small yellow contracted
large bright waxy plump	Comb	small dull dry shrivelled	white	Legs	yellow
			alert active friendly	Temperament	dull listless shy, timid

FIG. 233. There is a great difference in the depth of the abdomen of these two hens, The hen at the right has a depth of more than four fingers. The capacity of the hen at the left is much smaller. (Photo from Poultry Department, Kansas State College)

The body of a good layer is wide throughout its length, full breasted, and deep. The legs should be of medium length and flat on the sides. Crooked beaks, toes, or backs, and other malformations are not desirable. When a hen is laying or about to lay, certain characteristics become changed. The comb, beak, eye ring, ear lobe, skin, abdomen, vent, and legs of a hen that is not laying are as described in the "poor layers" columns of the foregoing chart. When the hen begins to lay, the condition of these parts changes until the conditions outlined in the "good layers" columns are evident. It is possible to learn a good deal about the length of time a hen has been laying by noting these changes. For example, the beak bleaches first at the base, and the colour gradually disappears towards the tip until it finally leaves the front part of the upper mandible—a bleached beak, on the average yellow-skinned bird, indicates that the hen has been laying for from six to eight weeks. The shanks lose colour last, and a bleached shank usually denotes production for at least eight to twenty weeks. When a hen stops laying in the summer, she usually begins to moult; therefore it may usually be considered that a late moulter has been laying for a longer period and is a good producer. A good layer is more friendly and more easily handled than a poor layer, which is usually shy and timid.

When culling, careful consideration must be given to the time of year, the age and breed of the birds, feed and range, and other factors, such as whether the birds are laying or not. Late summer and fall are good times at which to cull, but it has been suggested that continual culling is more profitable than a periodic plan—

that just as soon as a bird appears to be overfat and sluggish, it should be disposed of. In any case, thorough, intelligent culling is profitable.

The best layers. In one issue of *Guide to Farm Practice in Saskatchewan,* it was suggested that hens which have been the best layers, and which should therefore be kept for breeding, are those which (1) matured and laid early as pullets (at five to six months, depending on whether a light or heavy breed), (2) produced well during the winter, (3) did not go broody in the spring, and (4) moulted late and continued to lay during the late summer and early fall months.

Observations to secure the information suggested in the foregoing paragraph should be made several times a year, as follows: (1) in the fall, as pullets begin to lay; (2) in the latter part of December, to see which birds are laying; (3) in March, (4) later, during the "broody" season, and (5) again in September, to identify the birds which are not moulting but are still laying.

When the breeding season is over, the males should be separated from the hens, since infertile eggs will keep much better than fertile eggs. Unless they are quite valuable, the males should be killed for table use.

The male bird. The male bird is the most important individual in the flock. He should be strong and vigorous, of good body conformation, and free from breed disqualifications or other defects. His pedigree should show that his ancestors and their progeny have been heavy egg producers.

Pullorum disease. As we have already said, Approved Poultry Flocks must be tested for pullorum disease, a poultry malady which may cause serious economic loss by reducing egg production and causing high mortality among baby chicks. The disease is caused by a minute, rod-shaped bacterium, and spreads rapidly. The greatest losses occur during the first three weeks of the chick's life. Some chicks may die early without pronounced symptoms. Others affected are droopy, huddled, and inactive, and frequently

utter shrill cries as if in pain. Diarrhœa is often but not always present. Healthy chicks and adult birds may be carriers of the germ and may, therefore, infect an entire flock. Carriers may be detected by a blood test, and every bird (chickens and turkeys) in the flock should be tested by a qualified person, such as a provincial poultry culler. A tiny sample of blood, from a vein under the wing, is added to a drop of coloured antigen. If pullorum is present, the blood coagulates in thirty seconds. Tests are applied annually until the flock passes two consecutive negative tests, after which it may be considered to be pullorum-free. Following the stamping out of the disease in a flock, bi-annual tests should be conducted to ensure continual freedom. All eggs, chicks, and other stock introduced into a flock must be from sources where pullorum disease is definitely under control.

Coccidiosis. This disease is at present one of the greatest hazards in the poultry industry. It occurs most commonly during the second month of the chick's life, but may appear earlier; and older birds may develop a chronic stage. It is caused by a micro-organism and is transmitted from diseased to healthy chicks through the droppings. Symptoms are: droopy, inactive chicks with ruffled feathers; droppings tinged with blood; diarrhœa and lameness. Coccidiosis is being brought under control experimentally by certain supha drugs the use of which may be widespread in the near future. Prevention of the disease lies in a programme of careful sanitation.

Egg-laying contests. Registered pedigree poultry. The Dominion Department of Agriculture carries on an extensive national poultry improvement programme, which includes, in addition to R.O.P. work previously mentioned, egg-laying contests and approved hatchery regulations.

The Poultry Division, Experimental Farms, Ottawa, conducts egg-laying competitions periodically at Brandon, Indian Head, Lethbridge, and other points throughout the Dominion. Hens, to be eligible for any of the Canadian National Egg-laying Contests, must have been bred and raised by the contestant. Entries are

shipped to one of the above places and remain there during the contest. The objects of these competitions are to encourage the breeding of hens of greater production, to furnish reliable information about them, and to provide a system of qualification for the registration of poultry. Hens that conform to the standard of the breed and lay in a contest a minimum of two hundred eggs weighing at least twenty-four ounces to the dozen, and males free from breed disqualifications and bred from a dam and granddam of the foregoing qualifications, may be registered in the Canadian Livestock Records Association. Birds qualifying on R.O.P. standards in official Dominion Laying Contests are eligible for R.O.P. certificates.

Approved hatcheries. New flocks may be started by purchasing pullets ready to lay or adult breeding stock, but one of the most economical methods of making a beginning or building up an established flock is to buy baby chicks from an approved hatchery.

The source of baby chicks is of the greatest importance. In Saskatchewan and other provinces, it is compulsory for all hatcheries of over 1000-egg capacity to operate under Dominion Government Hatchery Approval Regulations. The hatcheries are inspected by federal government officials. Strictest sanitary conditions are maintained in incubator and hatching rooms. All eggs must be purchased from pullorum tested flocks and, when set, must average twenty-four ounces per dozen in tray lots. Chicks, when boxed, must weigh at least eight pounds per hundred. Approved hatcheries buy eggs from Government Approved Flocks to ensure chicks of desirable breeding and quality. Only healthy, vigorous chicks, true to type, are sent out to purchasers. Hatcheries found guilty of ignoring the regulations may be refused an inspection for a period of two years.

Incubation. Many chicks are still hatched by hens and incubators on the farm, although there is a growing tendency towards the purchase of chicks from commercial hatcheries for the purpose of maintaining poultry flocks.

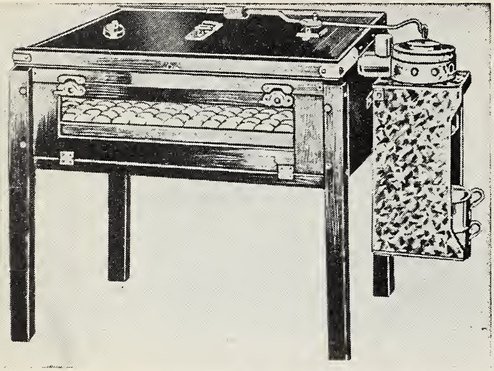

Fig. 234. An incubator for the farm. It is not wise to use one that is too small. (Photo from T. Eaton Co., Ltd.)

For hatching purposes, eggs should be uniform in size, not less than twenty-four ounces to the dozen in weight, of good shape, and as fresh as possible. Eggs that have been chilled, or are dirty or abnormally shaped, will not give satisfactory results.

Natural incubation. — Hens that are inclined to be broody are dusted with insect powder, and placed in nests for a day or two before being given eggs. The nests should be about twelve by sixteen inches in size. A piece of sod may be placed in the bottom, and the nest is shaped around the sides with straw or grass. Everything about the nesting place should be dry and clean. When it is found that the hen is going to sit, from twelve to fourteen eggs are placed under her. Each hen should be taken from the nest once daily for feed, exercise, and a dust bath, but at all other times should be disturbed as little as possible. A couple of days before the eggs hatch, the hen should be dusted again with insect powder.

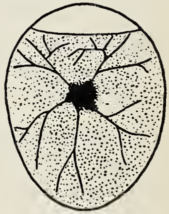

Fig 235. A fertile egg on the seventh day, as it appears when candled. Notice the veins and the large air space

Artificial Incubation.—When a hundred or more chicks are raised each year, an incubator is more satisfactory than hens, especially if early hatched chickens are desired. Incubators vary considerably in size; from 100 to over 2000 eggs may be set at one time, depending upon the size of the incubator. A lamp set below the egg chamber keeps the temperature at 103° Fahrenheit. A moisture pan, which must be kept filled with water, prevents too dry an atmosphere. Ventilation is

essential, particularly as the hatch progresses. After the second day, the eggs should be turned morning and evening until the eighteenth or nineteenth day. After the tenth day, provision should be made to cool the eggs once daily. With each incubator the manufacturer furnishes a complete set of instructions, which should be followed very closely to ensure successful results.

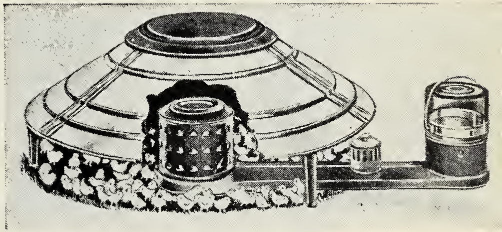

Fig. 236. An oil-heated colony hover or brooder for young chicks. (Photo from T. Eaton Co., Ltd.)

Eggs under a hen or in an incubator should be tested by candling on the seventh and the fourteenth days, and infertile or spoiled eggs should be removed.

Chicks should be reared away from older birds. The equipment best suited for the farm is a colony brooder, operated in a special brooder house or room. A good size of brooder house is 10 feet x 12 feet. It should be mounted on skids for convenience in changing the location to help in keeping it clean. Chicks should not be over-crowded, and as soon after they are a week old and as weather permits they should have an outdoor run. The brooder house should be dry, well ventilated, and lighted. A uniform temperature of 95°-100° Fahrenheit should be maintained at first and gradually reduced as the chicks mature.

The periods of incubation for the more common species of farm poultry are: for a chicken, twenty-one days; for a duck or a turkey, twenty-eight days; and for a goose, from twenty-eight to thirty days.

Rearing chicks. Chicks require no feed for a short time after they are hatched. For the first week or ten days, stale bread soaked in milk, pressed dry and mixed with hard-boiled egg, forms a good ration. A dry mash, consisting of equal parts of finely ground wheat, oats, and barley, with about ten per cent

meat meal or beef scrap, and a small amount of charcoal, salt, and cod-liver oil, should be constantly available to the chicks from the beginning. Grit should also be supplied. After the first four to six weeks whole grain should be supplied, beginning with two parts of good feed wheat and one part of finely cracked corn, and gradually changing to whole grain. The chicks will grow better if given buttermilk or skim-milk to drink. Why? A pasture of alfalfa or grass is desirable to supply green feed. Exercise, warmth, cleanliness, and shade are absolutely essential for growing poultry. Heat is especially important during the first few weeks.

The care and feeding of ducks and geese. Like chickens, ducks and geese thrive best in clean, dry surroundings. They require no water except for drinking purposes. A good range for exercise is essential. Finely ground wheat, oats, and barley are desirable in the ration, which should also include green feeds, such as lettuce leaves, etc., meat scraps, milk, and grit. The young fowl should be fed four or five times a day for the first few days. All grain feed should be ground, as geese, particularly, cannot make good use of these feeds when they are whole or cracked.

The care and feeding of turkeys. Turkey poults may now be purchased from approved hatcheries in the same manner as chicks. Young turkeys are delicate for the first few weeks, and should be carefully protected from dampness and lice. They should be fed frequently. The ration may consist of stale bread, soaked in milk and then pressed dry, and chopped hard-boiled eggs. Gradually shorts are substituted for the bread and eggs until the entire ration is composed of shorts and milk. In a few days, some cracked grain should be fed in the litter. Green feed, fresh water, charcoal, and grit are necessary at all times. Dry mash feeding, similar to that followed with chicks, should be carried out with young turkeys from the start until they are ready to fatten. After about four weeks, the turkeys may be allowed to roam at large; they will then pick up most of their

rations, but a hopper of dry mash should be provided, as previously suggested.

During the fattening period, turkeys should not be confined in too restricted quarters; in fact some authorities do not favour confining them at all. Feed at this time should consist of both mashes and whole grain such as wheat, oats, barley, and corn in various combinations. Fresh water and grit are necessary, as before. Turkeys thrive best out-of-doors, and should be allowed to roost in the open even during the fattening period. Some protection from rain and cold winds is desirable; turkeys should not be allowed to roost in draughty quarters.

NOTE.—For further information about the feeding and care of ducks, geese, and turkeys, the student should send to the Poultry Division of the provincial or Dominion Department of Agriculture.

In Saskatchewan, the Provincial Poultry Branch administers the Turkey Approval and Banding Policy. An approved turkey flock must include twenty-five or more disease-free birds of one breed only. Houses and equipment must be sanitary and otherwise acceptable. Turkeys in Approved Flocks are banded as Grade AAA (practically perfect birds), Grade AA (very desirable but minor plumage defects), and Grade A (good market type but defective plumage).

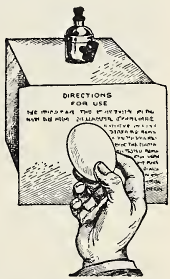

FIG. 237. An egg-candling appliance. This appliance and one suitable for use with a kerosene lamp are readily constructed from materials which should be available on the average farm.

THE MARKETING OF EGGS AND POULTRY

Eggs. The law requires that all eggs be candled before being sold to the consumer. The process consists of holding the eggs before a light enclosed in a special device in a darkened room. By this means the contents of the egg become fairly visible. (See Figure 238.)

The classes and grades of market eggs are as follows:

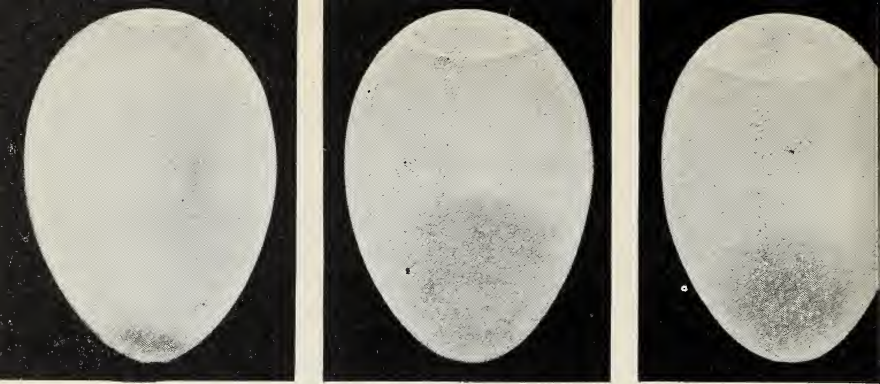

Fig. 238. Examples of eggs as they appear in candling. Left, Grade A, a very fresh egg, as indicated by the indistinctness of the yolk and the small air cell. Centre, a typical Grade B egg; notice the slight visibility of the yolk and the larger air cell. Right, Grade C, a stale egg with the yolk sunken and distinct, and a larger air cell. (Photo from Dominion Department of Agriculture, Ottawa)

Canadian Standards

Grade A1—clean, sound shell; yolk outline indistinct; yolk shadow reasonably small and round, maintaining position in central part of egg; yolk shall float freely around egg on twirling; no mottled yolks or visible germ spots; air cells less than $\frac{3}{16}$ inch; no floating air cells. Weight: Grade A1 Large, eggs weighing individually at the rate of 24 ounces and up to the dozen; Grade A1 Medium, at the rate of 22 to 24 ounces to the dozen; Grade A1 Pullet, at the rate of 20 to 22 ounces.

Note.—The term *clean* as used in these standards means "clean" not "cleaned." Only a very slight amount of dirt may be brushed off the shell. Brushing polishes the shell and this is objectionable. *Sound* means not only "not cracked" but as well "not ridged or porous."

Grade A—description same as for Grade A1 except air cell less than $\frac{1}{4}$ inch, and Grade A Pullet eggs may weigh individually 18 to 22 ounces to the dozen.

Grade B—reasonably clean, sound shell; yolk outline may be slightly visible, and yolk shadow slightly oblong but not definitely enlarged or flattened; yolk shall not rise completely to uppermost end of egg; yolk shall float freely around egg on twirling; no extremely mottled yolks or definitely pronounced germ spots; air cells less than $\frac{3}{8}$ inch; no floating air cells. Weight: large, 24 ounces to the dozen; medium, 22 to 24 ounces to the dozen; eggs less than 22 ounces to the dozen not allowed in this grade.

Grade C—all eggs, including cracked and soiled eggs, not permitted in Grades A and B but not unfit for human consumption. Cracked eggs shall be packed separately and the container marked.

The words "new laid" shall be used only in conjunction with Grade A1.

Cold stored eggs shall not be sold in Grades A1 or A. Such cold stored eggs may be sold only in the appropriate Grades B or C.

Grade A1 eggs may be packed only by producers authorized by the Dominion Department of Agriculture. Co-operative organizations or market groups may, on the approval of the Department, pack and market Grade A1 eggs for members eligible under this regulation.

Eggs should be shipped in strong, clean cases between good fillers and Mapes flats or Keyes trays which are composition trays with shallow pockets into which the eggs fit. An even layer of excelsior is placed under the bottom filler and on top of the upper filler in each case where Mapes flats are used. The lid should be securely fastened. Cases must be marked "ungraded eggs for shipment only," unless they are going direct to the consumer.

Dressed and eviscerated poultry. Poultry is processed, graded, and packed under strict government regulations and supervision in order to secure a high quality product for both the home and the export market. The term "dressed poultry" refers to poultry "from which the blood and feathers have been removed." A high quality type of poultry product being introduced into Canada (1948) is known as eviscerated poultry and is described as "dressed poultry from which the head, the legs at the hock joints, and all entrails and internal organs have been completely removed."

Poultry should be dressed as follows: The birds should be starved for a sufficient length of time before being killed to empty crops and intestines. Killing may be accomplished by thrusting a knife through the throat just behind the jaw bone. Bleeding should be properly done so that no blood remains in the extremities. All feathers must be removed except a few around the head. Feet, mouth, and vent must be cleaned. If there is any feed in the crop or crop discoloration, the crop

should be removed. Immediately after killing and dressing, poultry should be removed to the cooling room to be chilled to "an internal body temperature of 40° Fahrenheit or lower" and "shall be held at a temperature not exceeding 40° Fahrenheit when being graded, packed, and held for shipment or cold storage."

When a good price is paid for dressed poultry, the purchaser likes to know that good value has been received. When poultry bears government grade tags, the purchaser knows that he is receiving exactly the quality he is paying for. Except when sold directly from producer to consumer, all dressed and eviscerated poultry shall be processed and graded in registered "stations" and shall be marked in an approved manner to indicate the grade of each bird and the number of grading station, and the word "Canada." The Canadian government grades of poultry are:

Canadian Grades for Dressed Poultry

The following outlines have been secured largely from *The Dressed and Eviscerated Poultry Regulations* as they applied in 1948. Changing conditions necessitate changes in the standards. Teachers and students should endeavour to keep their knowledge up-to-date.

Grade Special (or Grade Special Milkfed in the case of chickens)—(*a*) normal physical conformation, no deformities, (*b*) well fleshed, breast full and well fleshed in relation to length and depth of body; in the case of turkeys the keel relatively long for size of carcass; breast flesh carried well over keel and well back to posterior end of keel; the width of breast at a point 1 inch back from the anterior (front) end of keel and two-fifths of the depth of the carcass equal to 80 per cent of the length of the keel, (*c*) breast, back, hips, and pin bones covered with fat in the case of chickens, and in the case of other poultry well covered with fat, (*d*) not more than five pin feathers on the breast or more than ten elsewhere on the body, (*e*) no prominent discoloration, (*f*) on the breast no more than one tear which shall be not more than $\frac{1}{4}$ inch in length, not more than two tears elsewhere on the body and not more than $\frac{1}{4}$-$\frac{3}{4}$ inches in length depending upon the kind of poultry.

Grade A (or Grade A Milkfed in the case of chickens)—(*a*) no deformities except a slightly crooked keel, (*b*) relatively well fleshed

in relation to length and depth of body, (*c*) breast, back, hips and pin bones showing fat in the case of chickens, and in the case of other poultry well covered with fat, (*d*) no more than six pin feathers on breast or more than twelve elsewhere, (*e*) no prominent discoloration exceeding $\frac{1}{2}$ square inch on the breast or 1 square inch elsewhere, (*f*) on the breast not more than one tear exceeding $\frac{1}{4}$ inch in length or more than three small tears; tears elsewhere not exceeding two and not more than $\frac{1}{2}$-$\frac{3}{4}$ inches in length depending on the kind of poultry.

Grade B—(*a*) normal physical conformation with the exception of a slightly crooked keel, (*b*) reasonably well fleshed, (*c*) sufficient fat to prevent a dark red appearance, (*d*) sufficiently well plucked that pin feathers remaining do not detract from appearance of bird, (*e*) no prominent discoloration exceeding 1 square inch, (*f*) on the breast not more than two tears exceeding $\frac{1}{2}$ inch in length, elsewhere not more than three tears $\frac{1}{2}$-1 inch in length depending upon the kind of poultry.

Grade C—fairly well fleshed, not badly discoloured, no tears exceeding 4 inches in length, no pin feathers that seriously detract from the appearance of the bird.

Grade D—all birds that do not qualify for the higher grades but which are fit for human consumption.

The term "milkfed" used in the case of chickens refers to top quality chickens, showing the right amount of fat and a fine soft texture in the skin. They are finished by proper feeding, preferably in crates or pens. Chickens grading "milkfed" have an attractive appearance and a fine delicate flavour.

Poultry processing, grading, and packing stations, in order to qualify for registration, must have adequate equipment, sanitary facilities, and means for cooling birds and holding them at a low temperature for grading and shipment. They must be kept clean. Workers must wear suitable and clean clothing. Dressed and eviscerated poultry must be packed according to definite specifications regarding style, weights, type of boxes, box markings, and inspection. The heads of all dressed poultry must be wrapped.

Egg and poultry pools. Pools market a large percentage of the poultry products of Western Canada. The principle on which a pool operates is that each member shares equally in the ex-

penses of marketing and in the profits in proportion to the amount and the quality of the produce he sells through the pool. The advantages resulting from carload shipments become available to the small producer.

Exercises

1. If there is an egg and poultry pool in your district, ask one of the directors to explain its operation to you.
2. How does the price received by one member of a pool compare with the price received by other members for the same grade of eggs or poultry?
3. Does the establishment of collecting centres and the shipping of eggs and poultry in large quantities reduce the shipping cost per dozen and per bird? Explain.
4. Should the consumers profit by the operations of a pool? How?

Pools may also serve both producer and consumer by emphasizing improved quality. High quality products usually demand higher prices and assure the purchaser of good value for the money he spends.

Exercises and Problems

1. By what special characteristics would you distinguish the following breeds of chickens: White Plymouth Rocks, White Wyandottes, White Orpingtons, and White Leghorns?
2. Write to the Poultry Division, Live Stock Branch, Ottawa, for information regarding the production and grading of eggs. Construct a candling apparatus, and examine a number of eggs.
3. Candle the eggs sold from home to prevent bad ones from being shipped off the farm.
4. Other bulletins dealing with phases of the poultry industry in which you may be interested may be secured by writing to the Poultry Division, Live Stock Branch, Ottawa (laying contests, R.O.P., hatchery approval, etc.), or to your provincial Department of Agriculture (flock approval, blood testing, etc.).
5. Arrange to have a demonstration in poultry culling or to watch a government inspector at work while he inspects a flock in your locality.
6. Try to visit poultry shows to study breed characteristics. If possible, watch the judges at work.
7. What are the chief problems in the poultry industry? Discuss production, management, flock improvement, marketing.

CHAPTER 15

FARM MANAGEMENT AND ECONOMICS

Farming is becoming more and more a business requiring considerable ability and skill on the part of the farmer. The farmer or farm manager of today must study very carefully the problems of his farm and gather all the information he can about them, in order to know whether or not he is doing the right thing at the right time and in the right way.

There are numerous details which the farmer should continually examine to prevent losses and consequent reduction of profits. He should know the most profitable crops and live stock to produce and the cost of their production; how much to invest in each; the cost of transportation and the method by which his products can be marketed to bring him the greatest returns. The plan and arrangement of his fields, the fertility of his soil, and the direction of his labour are also matters that demand his constant attention. These are the problems which the students of farm management seek to solve in order to make farming a less hazardous, and, at the same time, a more profitable business.

We have already discussed many phases of the subject, such as the management of the soil, the destruction of weeds and insect pests, the prevention of plant diseases, the production of crops and live stock, etc. But there are other matters which affect the success of the farming industry—such questions as the planning of the farm, the keeping of farm accounts, the cost of production, and the methods of marketing farm produce—which we shall consider in this and later chapters.

Farm accounts or farm bookkeeping. Inventories. In order to conduct the business of farming efficiently, some system

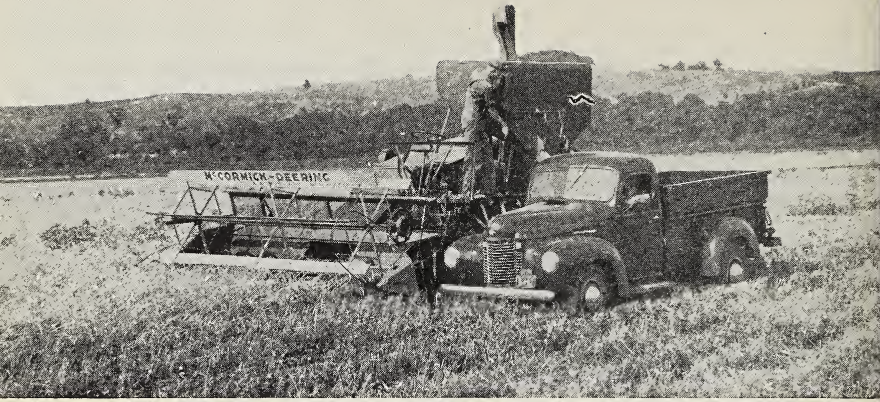

FIG. 239. An annual inventory will give a farmer much information about his business and his financial standing. Each item, such as the truck, combine, and land in this illustration, as well as all other equipment, live stock, and bills receivable and payable should be listed and valued. (Photo from International Harvester Co.)

of accounting is necessary. By making an annual inventory and keeping a set of accounts showing costs, yields, etc., it is possible to carry on the activities of the farm more profitably. The system should be as simple as the size of the farm will permit, so that the minimum time will be required to make entries and arrive at balances.

The farmer who keeps books gains several advantages; he knows at any time exactly what his financial standing is; and at the end of each year it is possible for him to determine what it has cost to produce his crops and to feed his live stock, and whether he has a profit or a loss. His books will show him which of his enterprises are the most profitable and which should be expanded or reduced. As a part of farm bookkeeping, many farmers find it helpful to prepare each year a map or plan of their farms, showing the crops being grown in each field and other important details.

When accounts are to be kept, proceed as follows:

1. Take an inventory of the capital, stock, and equipment of the farm, together with bills payable and bills receivable. List each item of the farm, and place a value upon it. The value should be estimated at fair market prices, that is, the price which the article would bring if offered for sale.

SAMPLE OF A FARM INVENTORY

INVENTORY 320 ACRES DECEMBER 31ST, 19......

	Quantity	Value per unit	Valuation
Real Estate			
Land....................	320	$40.00	$12,800.00
Improvements (house, barns, fences, etc.)............			5,200.00
Total...........			$18,000.00
Live Stock			
Cattle....................	3	$100.00	$ 300.00
Horses...................	2	80.00	160.00
Pigs (breeding sows).......	2	50.00	100.00
Poultry..................	52	1.00	52.00
Total...........			$ 612.00
Machinery and Tools			
Tractor..................	1	$1500.00	$ 1,500.00
One-way disk and seeder box	1	525.00	525.00
Binder..................	1	50.00	50.00
All other items, (to be listed)			785.00
Total............			$ 2,860.00
Farm Produce			
Wheat....................	400 bu.	$ 1.35	$ 540.00
Oats.....................	950 bu.	.50	475.00
Hay.....................	20 tons	12.00	240.00
Total............			1,255.00
Accounts Receivable			
Harry Jones' note for 1 cow ..			100.00
Cash on hand and in bank....			300.00
Total Value of Assets........			$23,127.00
Accounts Payable			
Mortgage on farm.........			2,000.00
Massey-Harris Co. machinery			200.00
Total Liabilities.............			2,200.00
Net Worth or Balance of Assets over Liabilities............			$20,927.00

When totalled, and after the liabilities, if any, have been subtracted from the assets, the inventory should show the farmer his net worth, or, in other words, exactly what he is worth financially. By comparing his net worth from year to year, he can determine whether his financial position is improving or not.

When arriving at an estimate of the value of the assets of the farm, allowance should be made each year for *depreciation*, that is, the gradual decrease in value of machinery, buildings, etc., due to wear and weathering. A general rule is to calculate depreciation on stone or cement buildings at $2\frac{1}{2}$ to 3 per cent per annum, on frame buildings at 5 per cent, tractors and trucks at 20 per cent, and other machinery at 10 per cent. Depreciation will, of course, vary a great deal on different farms.

2. Decide upon the accounts to be kept. The following have been suggested: a separate account for each class of live stock and for each crop or other enterprise, labour, tractor, feed, buildings, machinery and equipment, and possibly a general account to take care of items not provided for otherwise. Other essential records are bills receivable, bills payable, and cash. All labour items should be entered in the labour account, indicating the farm enterprise in which the labour was employed. If it is desired to determine the profit or loss resulting from an enterprise, the labour charged to it should be transferred to the account at the end of the year. In a similar manner all feed used is accounted for in the general feed record, and charged at the end of the year to the account of the live stock that consumed it.

3. To open the accounts, secure a suitable book and apportion space in it to each account. Enter values shown in the inventory in each account on the debit or expense side, except bills payable. Why?

4. Post or enter current entries from day to day as they arise.

5. To close the books, take an inventory, and this time credit each account (enter on receipt side), except bills payable. If it is desired to find the profit or loss of individual enterprises, charge labour and feed to the proper accounts. Charge each account with taxes, interest on money invested, etc. Balance each account to show profit or loss.

6. Total the gains and losses from the individual accounts, and determine the total profit or loss for the entire farm business. Or, if individual accounts are not being balanced, total all receipts and expenditures to arrive at the cash profit or loss for all the farm enterprises.

Accounts to be accurate and valuable, must be neat. It is a good plan to carry a small note-book and to enter in this the various items as they occur. At the end of the day the items should be posted in the regular account book.

There are several methods of keeping accounts. An example of one form is as follows:

SWINE ACCOUNT*

Date		Items	Expenses		Receipts	
		Enter swine purchased and other expenses chargeable to this account. *Enter sales as receipts.*				

Another method of organizing a set of accounts, the columnar system, is as follows: (one receipt account and one expense account are shown):

RECEIPTS FROM SALE OF CROPS

Date		Quantity	Price Received									
			Wheat		Oats		Barley		Rye		Flax	

EXPENSES: LIVE STOCK

Date		Quantity	Amounts paid out									
			Horses		Cattle		Sheep		Hogs		Poultry	

These accounts may be extended to the right as desired to include other items, as well as downwards. This method of accounting makes it possible to include much information in compact form.

*See also the wheat account on page 351.

Exercises

1. The following is a partial summary of some of the changes which occurred in the financial standing of the owner of the farm during the year following the taking of the inventory shown on page 345.

Feb.	3.	Sold calf $100.
Apr.	18.	Sold 100 bu. wheat (certified) @ $1.50 per bu.
May	26.	Jones paid note of $100 for cow in full.
June	16.	Bought milk cow $125 to replace one that died.
Oct.	25.	Sold steer $110.
Nov.	5.	Sold 12 spring pigs $35 each.
Nov.	15.	Paid Massey-Harris note of $200 in full.
Dec.	30.	Paid $500 on principal of mortgage.

During the year the two sows increased in value $10 each.
Depreciation on machinery—10 and 20 per cent.
There was on hand December 31st:

300 bu. wheat	@	$1.25
1025 bu. oats	@	.35
30 tons hay	@	10.00

Other transactions, such as the sale of the previous year's crop, money spent, etc., leave a balance of $500, to or from which the cash received or paid out in the foregoing transactions should be added or subtracted to calculate the cash balance in the bank at the end of the second year. The value of the land and buildings, the number and value of the live stock, etc., remain the same except where indicated above.

Make out the second inventory as for December 31st, and determine the change in the farmer's net worth.

2. A dairy cow was purchased for $85. Seven years later she was sold for meat for $37.50. Find the average annual rate of depreciation.

3. From farmers in your district find out how long a plough and other machines wear on the average farm.

4. Find out the cost when new of a number of machines. Using the information secured in Exercise 3, calculate the average rate of depreciation. Find the value of one or two machines at the end of the fourth year of use.

The cost of production. Profit in farming. Accurate accounts enable a farmer to ascertain exactly what it costs him to produce his crops, live stock, and other products. From these records it

FIG. 240. Feeder steers being finished on a prairie farm. The "cost of production" of each enterprise undertaken on the farm should be calculated to determine whether it is profitable or not. An enterprise being carried on at a loss may appreciably reduce the total net returns of the farmer. (Photo from Saskatchewan Department of Agriculture)

is possible to determine the number of tractor hours or horses and men required to perform the various operations of the farm, the cost of these per hour, the length of time required to prepare an acre for seed, to harvest the crop, to feed and care for the live stock, and all the other items that enter into the cost of production.

The methods employed, the cost of feed, etc., vary a great deal in different localities to suit varying conditions, and all of these are important factors in production costs. Costs are also greatly influenced by the acreage under cultivation, the system of crop rotation employed, the weediness of the fields, the type of machinery used, the skill of the farmer, and other factors. To arrive at a statement of costs in connection with various enterprises, it is necessary to determine the value of all items that affect the cost and to charge them against the enterprise concerned; for example:

Use of land: interest (at prevailing rates) on money invested, taxes, and upkeep per acre.

Use of buildings: depreciation, insurance, upkeep, and interest on buildings used to shelter live stock or to store feed and crop.

Man labour: wages, board, and lodging at current rates, calculated per hour of work.

Tractor costs: interest, depreciation, fuel, repairs, calculated per hour of work.

Machinery: interest, depreciation, repairs, and housing.

Share of summerfallow expense: charged to succeeding crops in ratio to the value received. For example, if a three-year rotation is followed, two-thirds of the summerfallow costs would be charged to the first crop and one-third to the second.

Seed: actual cost or prevailing market value.

Other factors: The exact nature of the items to be taken into consideration depends on the nature and the number of the enterprises being carried on.

The following examples illustrate methods of calculating costs:

The Cost of Fattening a Steer

Feed—at an average of 11.35¢ per day for 165 days..	\$18.72
Man labour, $\frac{1}{4}$ hour per day at 18.3¢ per hour........	7.53
Shelter..	1.00
Interest on money invested—8% of \$27.00..........	2.16
Total........................	\$29.41

Ration used: 15 lb. silage @ .25¢; 10 lb. roughage @ .125¢; 3 lb. barley @ 1.00¢; 2 lb. oats @ 1.00¢; 1 lb. bran @ 1.35¢.

The total cost of this steer may be arrived at as follows:

Buying price of 900 lb. steer in fall @ 3¢ per lb.......	\$27.00
Cost of care and feed...........................	29.41
Total........................	\$56.41

Steer should gain in 165 days at 1.5 lb. per day—247.5 lb.
Selling price of 1147.5 lb. steer in spring at 6.5¢—\$74.58

> Figures used in this section, or, in fact, in any part of this chapter, do not necessarily represent values for the current year or for any particular locality; they were reasonably accurate when compiled, but values vary greatly from year to year and from one part of the country to another.

The Cost of Producing an Acre of Wheat

The figures given in the account on page 351 are for 100 acres of wheat. The cost per acre can readily be determined by dividing the cost of each item by 100. Each student should calculate this for himself.

The cost per bushel could be arrived at by dividing the acre cost by the yield, but the yield varies so much from year to year that the acre cost appears to be more important, since it costs as much for ploughing, seeding, etc., and for taxes, insurance, and interest charges for a few bushels as for a crop of twenty bushels or more.

SAMPLE ACCOUNT

19—		Wheat (100 Acres of Fall Ploughing)	Expenses		Receipts	
		To cultivation with one-way disk	$ 15	00		
		To seed (125 bu. @ $1.50)	187	50		
		To cleaning and ceresan	25	00		
		To seeding and packing	100	00		
		To harrowing after seeding	25	00		
Aug.	15	To harvesting—swathing,	75	00		
		combining and putting in bin	200	00		
		To depreciation on machinery	70	00		
		To rent (interest on money				
		invested in land)	240	00		
		(taxes)	60	00		
		To insurance	60	00		
Sept.	15	To hauling to railway by truck	90	00		
Nov.	2	By net proceeds from sale of 1500				
		bu wheat at $1.70 less $300 for				
		freight and other selling expenses			2,550	00
		Profit	1,342	50		
			$ 2,550	00	$ 2,550	00

The profit in all farming operations or the net return to the farmer is determined by deducting from the receipts, all expenses and a fair rate of interest on invested capital. This net cash income must then be added to, or subtracted from, the increase or decrease in the inventory at the end of the year to determine the total profit or loss for the year.

The personal expenses of the farmer and his household should not be charged against the farm business.

Labour saving machines reduce costs. The use of labour saving machinery, of six- or eight-horse teams instead of two- or four-horse outfits, or of various sized tractors instead of horses, enables one man to handle a large acreage of land and thus very materially reduces the cost of producing farm crops. The combine is a good example of a large, expensive machine that can be used to reduce costs if there is sufficient work for it to do; the initial cost and the overhead expense of a large machine necessitate the owner having enough work for the machine to do to make

it a profitable investment. If used to full capacity, large machines will reduce the per unit cost of production.

Proper care of machinery is necessary. Not only the original price, but the repair and replacement expense of farm implements bulk large in the cost of production of farm products. The longer combines, trucks, and other machines can be economically maintained in good running order, the less they will add to the farmer's total expenses. Suggestions regarding the economical care of farm machinery are discussed on page 125.

Tractors versus horses. The use of tractors instead of horses, under certain conditions, reduces the cost of production. On one-quarter and one-half section farms, where there is not sufficient work for a tractor, where land is rolling, where there is water and pasture, and where fields are small and irregular in shape, horses may be more economical than tractors. However, on larger farms, tractors save expense by enabling one man to handle a large acreage, by reducing the amount of hired help required, by providing facilities for operating day and night shifts during rush seasons, and by otherwise making it possible to do a large amount of work in a relatively short time. The high initial cost, the cost of fuel and oil, and the high depreciation on a tractor may seem to be disadvantages, but these are offset by the reduction in the cost of operation if the area under cultivation is sufficiently large. The tractor, to be most economical, must be at work many days during the year; and large implements, or two or more smaller implements in combination, may be necessary to make full use of the power available. The extent to which tractors and horses are used varies widely. Some farms are operated with one or two six-horse teams; others have one or more horse outfits and a tractor. The six-horse outfit can be handled conveniently by one man and at the same time can cover a good acreage per day without tiring the horses.

Many grain farmers on the prairies, as well as in Eastern Canada, have no horses—they find a tractor the most economical source of power.

The size of the farm influences profits. The size of the farm is an important factor in its profitable operation. Larger farms provide for fuller employment of labour and the use of power machinery, and reduce overhead costs for buildings and equipment. The one-quarter section farm appears to be too small to be profitable except where special enterprises are carried on. One-half section and larger farms (in the Prairie Provinces, 400 to 1000 acres) offer greater opportunity for profitable operation. Expansion of the farm business should be based on a long range plan to take advantage of low prices for equipment and land. But larger farms also require greater skill on the part of the operator if he is going to avoid the losses which result from poor management.

High yields are necessary. Other factors which tend to reduce costs and increase profits in farming are: improved yields; more effective methods of controlling weeds, disease, and insect pests; and the use of crops of proven worth. The cost of cultivation, seed, the use of land, etc., are the same for a ten-bushel crop as for a yield of twenty bushels. Every effort should be made to see that every factor within the control of the farmer operates to produce high yields. However, although it is not likely to occur as a general rule, it is possible to increase yields beyond the point where the additional expenditure of time and money required, will return a profit.

Prices are important factors. Two main types of price changes affect farming profits. The first type includes the general changes that occur between periods of prosperity and depression. These affect not only the returns of the farmer but also the cost of his supplies and equipment and the value of his farm lands. The second type, which are shorter period changes, involves variations in the prices of individual products such as butterfat and cattle. They must be carefully studied from a long range viewpoint. Good results are not always obtained by expanding or decreasing farm enterprises on the basis of this type of price fluctuation.

Exercises

1. Ask experienced farmers to help you to answer the following questions: How many acres can be ploughed per day? harrowed? seeded? cut? stooked? What does it cost to perform these operations? What does it cost to clean and pickle wheat for seed? What is the price per bushel for combining wheat, oats, and other grains? What is the interest on the money invested in an acre of land? What are the taxes per acre? When each member of the class has secured as accurate information as possible, average the results, and estimate the cost of producing an acre of grain in your district.

2. In the example illustrating the cost of fattening a steer, on page 350, calculate the cost of producing one pound of beef if the steer dressed out 60 per cent when slaughtered. Your answer will, of course, be the cost on the farm, because the $74.58 does not include freight or other market costs.

3. An $8\frac{1}{2}$ foot one-way disk costs (with the box) $603. The annual charges against it are interest at 6 per cent, depreciation 10 per cent, and shelter $2. Find the cost per acre if 600 acres are cultivated. Repairs, of course, would increase the annual costs. What is the cost per acre the second year? What should the one-way disk sell for at the end of the second year?

4. A barn is worth $3000. It shelters 6 horses and 35 cows. Calculate the annual cost of shelter per head, allowing the following charges against the barn: 5 per cent for depreciation, 6 per cent for interest, $\frac{1}{4}$ per cent for insurance, $60 for repairs.

5. Post the entries in the following account, determine profit or loss, and balance the account.

As per inventory—5 cows @ $100 each—Dec. 31st, 19—.
Each cow averaged 30 pounds of milk per day for 300 days.
Milk tested 4 per cent butterfat, which was sold for 35¢ per pound.
Five calves were born—2 were sold for $10 each; the others were kept, and on the following December 31st, were worth $20 each.
Feed account shows each cow consumed feed worth $40.
Labour account shows $\frac{1}{3}$ hour per day man labour valued at $33\frac{1}{3}$¢ per hour for 365 days per cow. Interest charged at 6 per cent.
Shelter $5 for each cow. Pasture $20 for 5 cows.

NOTE.—Besides the preceding, the dairy cattle account should be charged with depreciation on dairy machinery used and with the cost of hauling the milk to town; but omit these and use the foregoing items only.

6. On the basis of current values in your locality for interest, taxes, labour, etc., estimate the cost of producing a crop of potatoes, a cultivated hay crop, or other farm enterprise.

Farm labour. The profitable employment of labour is one of the most troublesome problems confronting the farmer-manager. Sound judgment should be exercised in selecting men and in directing them, in order to avoid waste of time and effort. The most economical employment of labour demands a farming system that distributes the work evenly throughout the entire year. Arrangements should be made for doing chores, repairing fences, painting, etc., but such labour should be reduced to a minimum. When the labour is not required for the growing crops, it should be used for some other profitable enterprise. The use of labour saving equipment and methods of work is essential. Well planned farms and farmsteads are likewise helpful in the efficient use of farm labour.

A system which keeps a minimum number of men uniformly and profitably busy the year round has many advantages. It makes it possible to employ men for longer periods, and thus to secure a better class of help. Moreover, the man who has become familiar with the methods employed on the farm is more valuable than one who is unacquainted with them.

The cost per hour of man labour is calculated as follows:

Wages per month (30 days)	\$70 .00
Board and room per month	30 .00
	\$100 .00

10 hours per day for 30 days—300 hours.
Cost per hour—\$100 .00 ÷ 300 = $33\frac{1}{3}$ cents.

Exercises

1. Make enquiries about the cost of board and room in your locality. What are the farmers paying their men? Using this information, calculate the average cost per month of farm labour in your district.

2. Keep a record for a week of the number of hours of work done by each man on the farm, that is, from Monday morning until the following Sunday night. Calculate the cost per hour of man labour.

Types of farming. Farmers receive their cash income from the sale of grain, live stock, dairy products, etc.; therefore, the enterprise or enterprises from which the greatest portion of the farm income is received determines the type of farm. In the Prairie Provinces, the main type of farming is wheat production. Other types practised there are ranching and mixed farming. Dairying might also be considered the type for some farms enjoying particularly favourable conditions, but in the Prairie Provinces dairying is usually carried on in conjunction with some other type of farming. Farms on which the greater part of the revenue comes from a single enterprise are said to specialize in that particular type of agriculture.

Wheat production. Spring wheat thrives where the growing season is short and hot with a moderate rainfall. Broad, level fields, with soils rich in plant nutrients, are best adapted to its cultivation. With these natural conditions, and because wheat is usually sufficiently valuable to justify its transportation a long distance to market, wheat production is the most profitable enterprise for a large area extending over the prairie sections from east to west in Manitoba, Saskatchewan, and Alberta. For many years the common practice has been to summerfallow from twenty-five to fifty per cent of the land annually in order

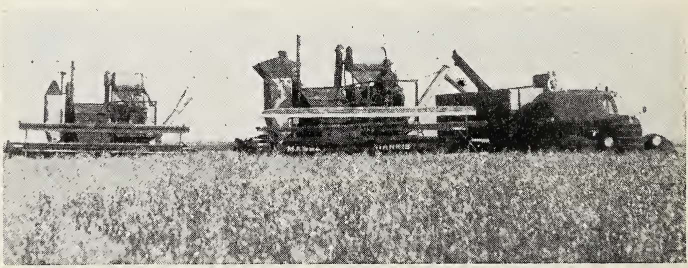

FIG. 241. Wheat-growing as it has been developed at present is a specialized type of farming that has been highly mechanized. These self-propelled combines are cutting wheat on a Western Canada farm. (Photo from Dominion Experimental Station, Swift Current)

FIG. 242. Water and pasture are essentials in areas where ranching is the predominant type of agriculture. (Photo from Dominion Experimental Farms Service)

to conserve moisture for the crop the following year as well as to control weeds.

Ranching. In districts where the moisture is not sufficient for wheat-growing but is ample to maintain a grass cover, the grazing of cattle, sheep, and horses may prove the more profitable enterprise. Land that is very rolling may be used to the best advantage for grazing purposes but facilities for watering stock are essential. These are found usually in natural reservoirs in coulees and other depressions in the land, which are fed from mountain streams or hillside springs. Winters with moderate temperature and light snowfall permit grazing during the greater part of the year. These natural conditions exist in the foot-hills of the Rocky Mountains, south-eastern Alberta, and south-western Saskatchewan. As the greater part of the revenue of the rancher comes from the sale of live stock, this type of agriculture is his specialty. In economic importance to the Prairie Provinces, ranching ranks below wheat production and mixed farming.

Mixed farming. In the eastern, northern, and western parts of Saskatchewan, bordering the prairie sections, are areas which have shorter frost-free periods, lower evaporation, and ranker vegetation. Where these conditions prevail, a smaller proportion of the acreage per farm is used for wheat, and in general summerfallow is of less importance than elsewhere. In these areas, oats and barley compete successfully with wheat. Forage

FIG. 243. Where a ready market is available, dairying is a profitable type of farming. (Photo from Dominion Department of Agriculture, Ottawa)

crops thrive there also. These are used for fattening live stock, such as cattle and hogs, on the farms where the feeds are produced; this is the best way of marketing coarse grains and forage.

The combination of several enterprises on one farm is known as mixed or diversified farming. With mixed farming, revenues are obtained from a number of different sources, thus spreading the risk; fuller employment of labour is possible; and wasteland and by-products can be used to better advantage. On many farms, a main enterprise, balanced by one or more secondary enterprises, will usually produce the best results over a period of years. The choice of the main enterprise or enterprises will depend largely upon the location of the farm with respect to markets, the nature of the soil, water supply, and the aptitude of the farmer. Mixed farming is an important type of farming in Eastern Canada. (See also page 35.)

Dairying. Perishable products, or products that are bulky for their value, usually pay best when produced near the consumer. Whole milk is such a product, and consequently it is produced for sale in the Prairie Provinces on only a limited number of farms situated near the towns and cities. In districts more remote, the important dairy product is cream, which may be shipped to creameries. Cream, in these districts, however, is usually only a by-product of a herd of cattle which is being raised primarily for the production of beef. In the Prairie Provinces the number of specialized dairy farms is relatively small, but most farmers have enough cattle to supply their own need for dairy products, and a considerable number have surpluses available for sale. In Ontario, dairying is a leading type of farming.

Capital required to start farming. How available capital is best expended. To begin operating a farm requires a reasonable amount of capital. It is impossible to specify exact amounts; much depends upon the type of farming being undertaken, the current value of land, machinery, etc., and the experience and skill of the person undertaking it. One man might be able to start with much less capital than another would require. All we can do here is to indicate briefly the chief matters to which consideration should be given:

Land is required. It may be rented, or purchased on long term payments.

Buildings are necessary. It is possible for a man and his family to begin with a small house, barn, and other buildings costing only a few hundred dollars. In some areas, logs may be secured for the construction of at least a part of the buildings.

Equipment is essential. The amount of equipment needed will depend to some extent on the size and the type of the farm. The necessary equipment for a small grain farm, for example, might consist of the following: one small tractor, one trailer or truck, one 8-foot one-way disk with seeder box, one 8- or more section drag harrow, one 10-foot cultivator, one fanning mill, one swather and combine or share in one, one team of horses, feed for horses, one mower, hay rake, rack, one wagon and box, seed grain, possibly a cow and chickens.

In addition to the above expenditures, consideration should be given to living expenses, taxes, the cost of harvesting the first crop, fuel, fencing, digging a well, etc.

The capital required for a start will, of course, vary greatly in different parts of the country. If new land is to be opened up, the cost of breaking will add to the initial expense, especially if the land is treed. Each individual must calculate his own requirements. He should prepare a list similar to the foregoing one, and, after finding out the current cost of new or possibly second-hand equipment, arrive at an estimate of the minimum cash outlay required to make a beginning.

It is usually wise to begin farming in a comparatively small way, gradually strengthening and enlarging the business from year to year. Experience has proved that, when large farms are purchased with borrowed capital, heavy interest charges very frequently make it exceedingly difficult for the owner to operate profitably, even after a period of many years. It would probably be wiser for persons with limited capital to rent land until they have adequate equipment free of debt, than to assume debt in connection with the purchase of land.

Exercises and Problems

1. Students who are interested in obtaining a more accurate statement of the capital required to start farming than that outlined in the foregoing paragraphs, should, as suggested, make a list of requirements and find the total cash outlay that appears to be required. Consult with people who have had experience in similar enterprises.
2. Discuss the factors that would have to be considered by a person who was comparing the various types of farming with a view to making a start in some farming enterprise. Mention personal likes, dislikes, and experience; location; land values; water supply; distance to market; capital required, etc.
3. Make a survey of your locality to determine the types of farming being carried on. Which one, if any, predominates? Ask several farmers why they selected the type of farming in which they are engaged.
4. Which, in your opinion, are more important factors in reducing the cost of producing farm crops, increased yields or improved labour-saving machinery? Give reasons for your decision.
5. In your opinion, what is the greatest advantage which the busy farmer derives from taking time to keep accurate records of the expenditures and returns from his various farm enterprises?
6. Compare horses and tractors as sources of power on the farm. Mention the initial cost, the overhead and upkeep (interest, shelter, fuel, feed, repairs, etc.), the size of the farm, the length of the annual working season, the years of low farm values and prices, and any other factors you consider important.
7. Mixed farming has many advantages. Discuss these as well as possible disadvantages.

CHAPTER 16

THE MARKETING OF FARM PRODUCTS

Marketing of farm produce. The marketing of the products of the farms of Canada is a story of outstanding achievement and organization, of which only a part can be told in this book. The selling of his products is one of the greatest problems confronting the farmer since the profits from his finest crops or live stock may be very greatly reduced by unwise marketing. One of the first questions to be considered in marketing is that of costs.

Exercise

After the crop is harvested and threshed, there are many expenses to be met before it is finally disposed of. Estimate some of these, as follows:

The grain must be hauled to a railroad. Trucking costs may range from three cents per bushel for a five mile haul to seven cents for fifteen miles.

At the elevator a charge is made for loading the grain. Appoint a committee from the class to visit the elevator to ascertain this charge per bushel.

The railroad collects a freight charge for hauling the grain to the terminal elevator. Another committee should learn the rate from the local station agent. Is the grain from your district shipped to Vancouver or to the head of the Lakes?

A commission firm will make a charge for selling the grain. Information regarding this charge may be secured from a farmer or elevator agent.

When each of these charges has been found, calculate the total cost of marketing a bushel and a carload of wheat.

The marketing of live stock incurs similar expenses. First, there is freight to pay. Then, when the stock arrives at a central market, it must be unloaded, put into special pens, and fed and watered, for all of which the farmer must pay, as well as a commission to the selling agent.

FIG. 244. Prize winning pen of lambs at a Feeder Show held at the Southern Saskatchewan Co-operative Stock Yards, Moose Jaw.

Another important consideration is connection with marketing is the question of selling price. If the farm produce is disposed of at the wrong time, a lower and perhaps unprofitable price must be accepted.

Since mistakes in marketing may so quickly change profits into losses, its importance is obvious. Every farmer should study very carefully the most economical methods of disposing of his grain, live stock, garden crops, etc., and should know exactly the time of year when the demand for his products will be the greatest, and the price, therefore, the most profitable.

Co-operation in selling and buying. In order to reduce the cost of marketing, many producers are now disposing of their grain, live stock, etc., co-operatively rather than individually. There is probably a co-operative association in your district. You might discuss the merits of such a system with its members.

One of the greatest advantages that the farmer derives from selling co-operatively is that his expenses may be much less than they would be if he undertook to do his own marketing. For example, each of four farmers has five steers to sell. To ship these to market separately would cost each farmer the freight charge on a whole car; but if they agree to ship co-operatively, the twenty head of cattle can be forwarded in one car, and each farmer is then required to bear but a quarter of the expense.

The same principle may also be applied to the purchasing of supplies for the farm. A carload of apples, for example, might be brought into a district and distributed to the farmers much more

economically than if the same apples were purchased by the farmers individually.

When the farmers of a district decide to co-operate, they usually organize a co-operative association. A president and other officers are elected, and a capable manager is appointed. An association that is truly co-operative makes no profit for itself, but returns all earnings to the members in proportion to the business that each has conducted through the association. Expenses are met by a charge upon the members, this charge being the same per unit bought or sold, irrespective of the volume of business which each member has contributed. For instance, the association may dispose of twenty head of cattle; in the shipment, one member has only one steer, while another member has five; the former would pay only one-twentieth of the total cost, while the latter would pay one-quarter. To be most successful, the association must see that produce, such as eggs, dressed poultry, butter, etc., offered for sale, is of the highest quality, and is presented to prospective purchasers in as attractive a manner as possible. In this way an association may establish a reputation for its goods, and develop a wider and more permanent market for what it has to sell.

The advantages that may result from co-operation are as follows: A true co-operative association seeks to sell directly to the consumer. As a result, the total value of the product sold, less handling expenses, is returned to the producer. In buying, the co-operative purchaser goes direct to the producer and receives whatever discount goes with a large scale purchase. Produce sold co-operatively is usually in such quantity (carload lots, etc.) that it frequently brings higher prices than would be obtained for small lots; in the purchasing of large quantities it is often possible to secure a lower price than that which would be demanded for small quantities. The handling expense per unit in buying or selling co-operatively is often much lower than that incurred by the individual farmer; the man with the small quantity of produce to sell can get his marketing done at the same rate per unit as the

Fig. 245. The Saskatchewan Wheat Pool owns 1165 country elevators with a combined capacity of sixty million bushels. (Photo from Saskatchewan Wheat Pool)

man with a large quantity; when several farmers unite to make up a large shipment, it is possible to reduce the cost per unit to a minimum, and better shipping facilities can usually be secured. A well organized co-operative association is able to afford the expense of a paid expert to direct buying and selling operations. Through co-operation, the quality of the produce of a district can be raised and standardized so that, when it is placed upon the market, a better price is obtained.

Principle of standardization. The following example will illustrate the principle of standardization. Let us suppose that you are an egg-dealer and that you buy a large number of eggs from a certain district. The eggs offered to you by the farmers in this district vary a great deal in freshness, size, cleanliness, and other respects. At times you are obliged to sell some of the poorer eggs at a very low price and may even lose money on them. As a result of this lack of uniformity, you are not able to pay any of these egg-producers as much as, perhaps, some of their produce is worth. By organizing co-operatively, the farmers of this community could meet, discuss the situation, and standardize their product. Eggs not up to the required quality would not be marketed by the organization. By these methods the district as a whole would build up a reputation for eggs of high quality. You, as a dealer, and others would be willing to pay higher prices for eggs from this district because you could depend upon every dozen being of uniformly high quality.

The principle of standardization can be applied to the marketing of honey, dressed poultry, and other farm products for the purpose of increasing the profits of the farmer.

Handling the Canadian wheat crop. The disposal of Canada's annual wheat crop is a tremendous undertaking. There are many classes and grades of grain, and each presents its own problems of marketing.

The methods of selling grain. When the grain is sold at the elevator in wagon lots, it is called *street grain*. The farmer and the elevator agent agree upon the grade of the grain, and the grain is paid for at the street price quoted for that particular day.

Larger quantities, or carload lots, of wheat are handled in a somewhat different manner. The farmer may load his car over the platform or through the elevator, the procedure varying in some respects in each case.

(*a*) When wheat or other grain is to be loaded by the farmer himself over the platform, he must first order a car from the station agent. When the car is in place, the wheat is hauled to town and loaded. The car is then sealed and billed to a commission agent or grain broker. At Winnipeg the wheat is graded, and, when it reaches the head of the Lakes, it is weighed and unloaded into the terminal elevator, where it may be stored for fifteen days free of charge. The commission agent then sells the grain according to instructions given him by the farmer. Within twenty-four hours after the wheat is sold, the farmer must be sent a complete report of the sale. He is then paid the price received minus freight, or other charges against the grain, including the agent's commission. This method of loading the grain saves handling expenses at the elevator.

(*b*) Wheat may be loaded through the elevator in either of two ways, by the special bin method or by the graded grain method.

(1) *Special bin method.*—The farmer who wishes to load his grain through the elevator by this method arranges for a special

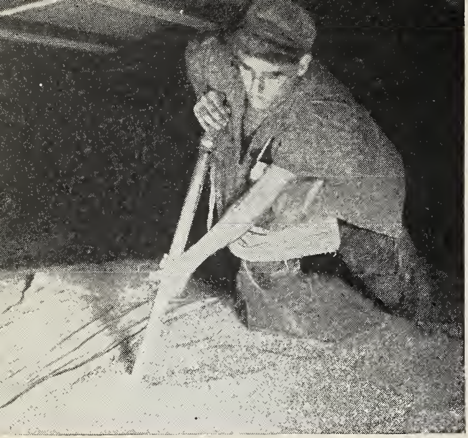

FIG. 246. Using the probe, or "stabber" to take samples of grain from a car. (Photo from *C-I-L Oval*)

bin at the elevator, and the identity of his grain is thus preserved. He is allowed fifteen days' free storage in which to haul in his wheat. As each load is brought in, it is weighed, and the farmer receives a special bin ticket, showing the weight of the grain in the load. He is charged from $1\frac{3}{8}$ to $3\frac{1}{2}$ cents per bushel, which covers storage, handling charges, and insurance while his wheat is in the elevator. When enough to fill a car has been hauled in, it is loaded and shipped. If the farmer pays the above charges, he can ship his grain to any selling agency he wishes. But if these charges are not paid, the company owning the elevator ships the wheat to its own terminal elevator, sells it as ordered by the farmer, and sends him the price received, less freight, commission, and the above charges.

(2) *Graded grain method.*—If the farmer does not wish to have a special bin, he and the elevator agent agree upon the grade and dockage of each load, and the farmer receives a graded ticket for each load; this ticket shows the net bushels of the load, the grade, and the dockage. By this method the farmer's wheat loses its identity. The grain of several farmers is unloaded into one big bin. Since the elevator can handle more grain with less trouble by this method, it is cheaper than having special bins.

Spot and track wheat. Wheat that is loaded and ready for transit but not inspected, is called *track wheat.* Grain unloaded in the elevator at a primary market is known as *spot wheat.* Spot wheat is usually from one to three cents higher in price than track, because it is on hand ready for delivery, while track wheat is in transit and may be delayed and thus not available when required.

The grading of Canada's grain crops. Each car of wheat, on its way to the head of the Lakes, is stopped for a short time at Winnipeg. A group of government men break the seal on the door, and remove a small sample from the car. The sample is taken by means of a long, slender, pointed probe, which consists of two perforated metal cylinders, one fitting inside the other. The cylinders may be turned so that the perforations are opened or closed (as in the top of a talcum powder box). A man enters the car and thrusts the probe, closed, vertically into the grain. The probe is then opened, to allow the grain to fill it, after which it is closed. In this way a sample is secured from top to bottom of the grain in the car. Similar samples are removed from various parts of the car, each being emptied upon a canvas at the door. When sufficient wheat has been taken to ensure a representative sample from the car, the grain on the canvas is thoroughly mixed, and a small bag is filled from it. A tag bearing the number of the car is tied to the bag, which is then hung just outside the car door. It is the duty of one of the men to re-seal the car doors and gather the bags.

The grading is done by skilled government inspectors in the Grain Exchange Building, Winnipeg. Each sample is carefully examined and compared with standard samples. The grain is also weighed to determine its weight per measured bushel. By means of sieves, the percentage of weed seeds or dockage is determined. Finally, the grade is decided upon, and the sample is filed away to be available in case the farmer disputes the grading. A report of the grade is sent to the commission firm to which the car is billed. Grading in Western Canada is also done at Calgary and other prairie centres, and at Vancouver and Prince Rupert.

Our system of grading grain is a great advantage to buyers. As all milling wheat is sold by highly standardized grades under strict government supervision, a buyer in a foreign country, for example, can safely purchase Canadian wheat without seeing it, and be certain of the quality of the wheat for which he has contracted.

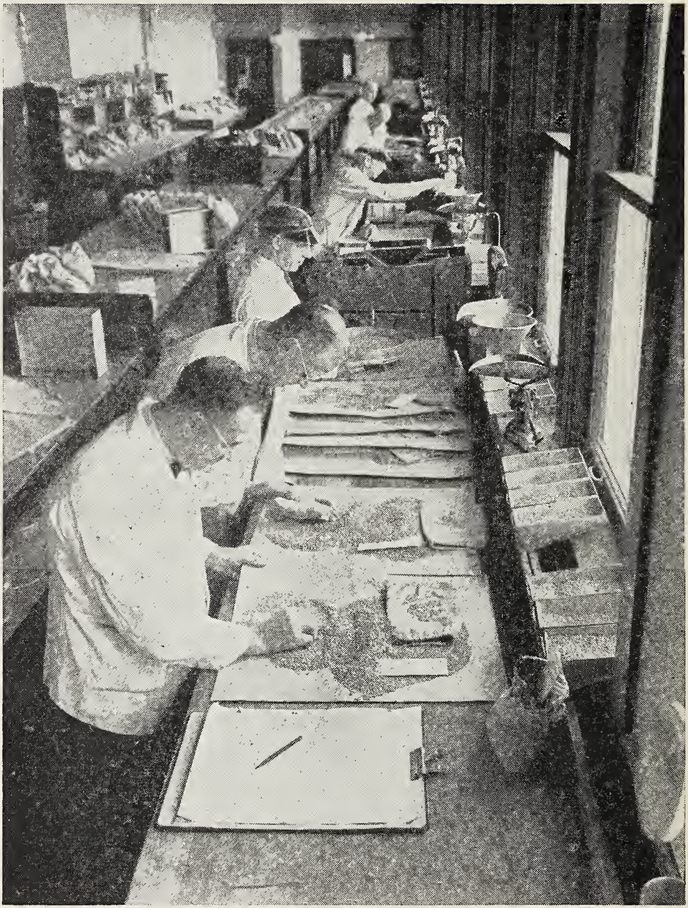

Fig. 247. Canada's grain crops are graded by experts who serve a long apprenticeship. The first two men above are examining samples. The third man is using a sieve to determine dockage. Notice the scales on the window sill for use when finding the weight per measured bushel of a sample. Grading grain according to standardized grades enables farmers who produce high quality grain to secure the advantage of the better prices paid for the top grades. (Photo from *C-I-L Oval*)

The Canada Grain Act (administered by the Board of Grain Commissioners of the Dominion Department of Trade and Commerce) defines the statutory grades. Each year soon after August 1st, the Committee on Grain Standards selects standard samples for each statutory grade, and sets commercial grades for wheat which cannot be graded in the statutory grades.

The Canadian grades of Red Spring Wheat. Grades have been established for wheat as follows: Red Spring Wheat, Garnet, Winter Wheat, Amber Durum, etc. It is possible here to outline only the Red Spring Wheat grades. Notice the rigid standards set for the various grades.

(*a*) STATUTORY GRADES.—

No. 1 Manitoba Hard (62 lb.); variety, Marquis or equal to Marquis; 80 per cent hard, vitreous kernels; sound and well matured; clean; minimum weight per bushel, 62 lb.

No. 1 Manitoba Northern (60 lb.); variety, Marquis or equal to Marquis; 65 per cent hard, vitreous kernels; well matured; practically free from damaged kernels; practically free from matter other than cereal grains; practically free from Durum; total wheat of other classes including Durum, about 1 per cent; minimum weight per bushel, 60 lb.

No. 2 Manitoba Northern (58 lb.); variety, Marquis or equal to Marquis; 50 per cent hard, vitreous kernels; reasonably well matured; reasonably free from damaged kernels; practically free from matter other than cereal grains; total including cereal grains other than wheat, about 1 per cent; Durum about 1 per cent; total wheat of other classes including Durum, 3 per cent; minimum weight per bushel, 58 lb.

No. 3 Manitoba Northern (57 lb.); any variety of Red Spring Wheat of fair milling quality, excluding Garnet; 35 per cent hard, vitreous kernels; excluded from higher grades on account of lightly frosted, immature, or other light damage; reasonably well matured; reasonably free from matter other than cereal grains; total including cereal grains other than wheat, about 2 per cent; Durum, 3 per cent; total wheat of other classes including Durum, 10 per cent; minimum weight per measured bushel, 57 lb.

No. 4 Manitoba Northern (56 lb.); any variety of Red Spring Wheat, excluding Garnet; reasonably well matured, but excluded

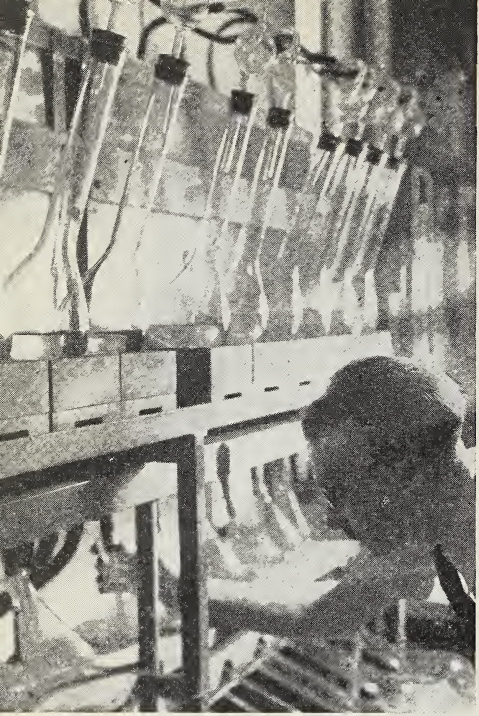

FIG. 248. Testing the protein strength of grain. (Photo from *C-I-L Oval*)

from preceding grades on account of frosted, immature, or other damage; reasonably free from matter other than cereal grains; total including cereal grains other than wheat, about $2\frac{1}{2}$ per cent; Durum Wheat, 4 per cent; total wheat of other classes including Durum, 10 per cent; minimum weight per measured bushel, 56 lb.

No. 4 Special (53 lb.); any variety of Red Spring Wheat; rusted or shrunken, but otherwise reasonably sound and reasonably well matured; reasonably free from matter other than cereal grains; total including cereal grains other than wheat, about $2\frac{1}{2}$ per cent; Durum Wheat, 4 per cent; minimum weight per measured bushel, 53 lb.

(*b*) COMMERCIAL GRADES.—

No. 5 Wheat is defined as follows: 53 lb. to the bushel; Red or White Spring or Winter Wheat varieties containing from 25 to 50 per cent of thin, immature, green, or damaged berries, not more than 3 per cent of barley or oats, and not more than 5 per cent of Amber or Red Durum.

No. 6 Wheat: 51 lb. to the bushel; Red or White Spring or Winter Wheat varieties, fully developed as far as weight is concerned but generally damaged by frost or thinness; at least 15 per cent of sound wheat, not more than 3 per cent of barley or rye, and not more than 6 per cent of Amber or Red Durum Wheat.

Feed Wheat is wheat containing too many frosted or unsound berries to grade higher; composed of wheat of any variety or varieties; about 3 per cent large seeds, or mixed Feed Oats, or in combination; total including cereal grain, about 13 per cent; all Feed Wheat will be made C.C. (cleaned until clean) for Mixed Feed Oats when containing $3\frac{1}{2}$ per cent or more over the grade allowance.

(*c*) Wheat containing more than 5-8 per cent of sprouted kernels is graded lower; *e.g.* Rejected No. 3 Northern Sprouted.

(*d*) All wheat infected with smut is classed as *Smutty*.

(*e*) All excessively moist wheat is classed as *Tough* or *Damp*.

(*f*) All wheat that is badly mixed with other grains or with weed seeds that cannot be removed, that is badly damaged, musty, sprouted, heated, or mixed with cinders or gravel, or that has an objectionable odour is classed as *Rejected*.

The class is added to the grade to which the wheat belongs, with a note as to cause and condition. Examples of such grades are No. 2 Northern Smutty, No. 4 Northern Tough, or Rejected No. 3 Northern Mixed Heated.

Grades of Oats. Grades of oats are also established by the Canada Grain Act. The first three grades of oats are defined as follows:

No. 1 Canada Western White; 38 lb. to the bushel; 95 per cent white oats; well matured and practically free from damage; free of other grains and not more than 1 per cent of wild oats and other grains.

No. 2 Canada Western White; 36 lb.; 90 per cent white oats; well matured; practically free from damage; not more than 3 per cent seeds, wild oats, and other grains.

No. 3 Canada Western White; 34 lb.; domestic oats; any variety; reasonably well matured; practically free from damage; not more than 6 per cent seeds, wild oats, and other grains.

There are also grades of Feed Oats.

Spot, track, or street wheat distinguished from the grades. Spot, track, or street wheat must not be confused with the grades of wheat. These names are given to classes of wheat according to their location or to the method by which they are being sold, and are not grades. Any of the grades of wheat in transit are track wheat, and any grade unloaded in the elevator at Fort William is classed as spot wheat.

The Grain Exchange. A Grain Exchange is an organization of men or companies who are engaged in buying and selling grain. The Grain Exchange itself does no buying or selling, but provides the place and the regulations under which trading transactions

may be conducted. It also provides complete and timely information bearing on all aspects of the grain trade from all parts of the world. There are exchanges at Winnipeg, Vancouver, Liverpool (England), Duluth, Chicago, Minneapolis, and other points. The members of these exchanges make their business the selling of the farmer's grain; they charge the farmers a commission for their services.

The advantage of an exchange to the farmer is that through it he can sell his grain to purchasers whom he could not otherwise reach—for example, buyers from other countries.

Many farmers object to the following features of the exchanges: The system allows speculation. There are middlemen, whose profits reduce the net returns of the farmer. In selling through commission firms, each farmer acts individually, and, when large numbers of farmers dispose of their grain immediately after harvesting, the market may be flooded, with the result that the price is forced down. As many farmers are compelled by financial circumstances to sell their grain early in the fall, they are obliged to accept the low price. The farmers want a long-term, orderly market, free from frequent and wide price fluctuations.

On the other hand, many people contend that speculation stimulates the market and makes possible the sale of grain at times when, if there were no speculation, there would be no demand for the grain.

Cash and future markets. All grain is bought and sold for cash, but it is not all necessarily cash grain. *Cash grain* is the term applied to grain that is bought or sold and delivered immediately. *Future grain* is grain that is purchased or sold but is not to be delivered until a future date. The delivery months on the Winnipeg Grain Exchange are October, November, December, May, and July. For example, December grain is sold and purchased early in the season for delivery in December.

The future market offers opportunity for trading and for speculation. For example: A man buys 2000 bushels of May oats in the fall at 72.5 cents per bushel. He does not have to take

delivery until the end of April. If at that time the price has risen to 80 cents, he will make a profit of 7.5 cents per bushel, or $150. On the other hand, a drop in price before May would result in a loss instead of a profit.

In Canada there is no trading in wheat, as all wheat has for several years been marketed through the Canadian Wheat Board, which was also authorized to take over marketing of western oats and barley on August 1st, 1949.

Operation in the pit of the Grain Exchange. All buying and selling on the Winnipeg Exchange is carried on in a large room in the Grain Exchange Building. In one part of the room are two circular platforms, with steps leading up from the outside towards the centre. These platforms are known as "pits." On the pits the representatives of the companies who are members of the Exchange meet to buy and sell grain. The market opens at 9.30 a.m. and closes at 1.15 p.m.

The activities of the grain merchants are noisy but nonetheless very efficiently organized. Each man on the floor of the pit calls loudly the kind and number of bushels of the grain which he has for sale or desires to purchase. A series of signs, made by holding the hand and fingers in different positions, has been arranged so that the men can signal to one another. When an agent hears the kind of grain he wants being called, he signals to the caller, and by signs they complete the transaction. Each then notifies his office by means of messenger boys. These boys are constantly hurrying about, carrying communications back and forth between the offices of the firms and their representatives on the floor of the pit. The sides and one end of the room are lined with telephone booths. About one-third of the entire floor space is occupied by telegraph operators who are continually sending reports to and receiving reports from other exchanges. The fluctuations in the prices prevailing at the Winnipeg exchange and the information from other exchanges are posted on large bulletin boards.

Thus the market goes on throughout the morning. The price of each kind of grain rises or falls according to the demand for it.

The principle involved is known as the law of supply and demand. If there are few buyers and large quantities of grain for sale, the price drops; when the supply is limited and the buyers are plentiful, the price goes up. Reports coming in relative to crop and market conditions in other parts of the world also influence the price, so that it is almost impossible to know one minute what the price is going to be a moment later.

Exercises

1. From the market page of a daily paper or a farm magazine cut out the grain quotations, and paste them in your book. They will be found in various forms and headings. The following is an example:

Grain futures

WINNIPEG

Thursday, Sept. 2, 1948

Oats	Open	High	Low	Close	Prev. Close
Oct.	73.5	73.6	72.1	72.1	73.4
Dec.	71.2	71.3	69.5	69.6	71.1
May....	73.3	73.5	71.7	72	73.4
Barley					
Oct.	101.7	102.1	100.7	100.7	102
Dec.....	100.4	100.4	99.1	99.1	100.3
May ...	100.4	100.4	99.3	99.3	100.4

Flax	Open	High	Low	Close	Prev. Close
Nov.....	414.3	414.4	414.3	414.3	414.3
Dec.	407.4	407.4	407.2	407.4	407.4
May ...	—	—	—	413.5	—
Rye					
Oct.	146.2	146.2	142.4	144.1	146.4
Dec.	145	145	141.7	143	145.1
May....	144.6	145.2	144.6	145.6	148

The *open price* is the range of quotations recorded within the first two minutes after the market opened at 9.30 o'clock; *high* is the highest price during the morning; *low* is the lowest price; *close* is the price when the market closes at noon; and the *previous close* is the closing price of the day before.

2. Compare price quotations daily for a week, and observe the fluctuation that occurs.

3. Make a graph of the fluctuation in the price of one class of grain—for example, May rye—for a month or more. Secure a sheet of graph paper or rule a blank sheet into squares one-eighth of an inch in size. Mark the days on a horizontal line across the top of the page, and the price along a vertical line at the left of the page. Each day locate the price at the proper place on the graph. Join the prices marked, and the resulting line will indicate the daily fluctuations.

4. Why were there no quotations for wheat in the Grain Futures prices listed in Exercise No. 1? What other grains would also be omitted now? Why?

The co-operative marketing of wheat. The efforts of farmers to improve certain unsatisfactory conditions under which they

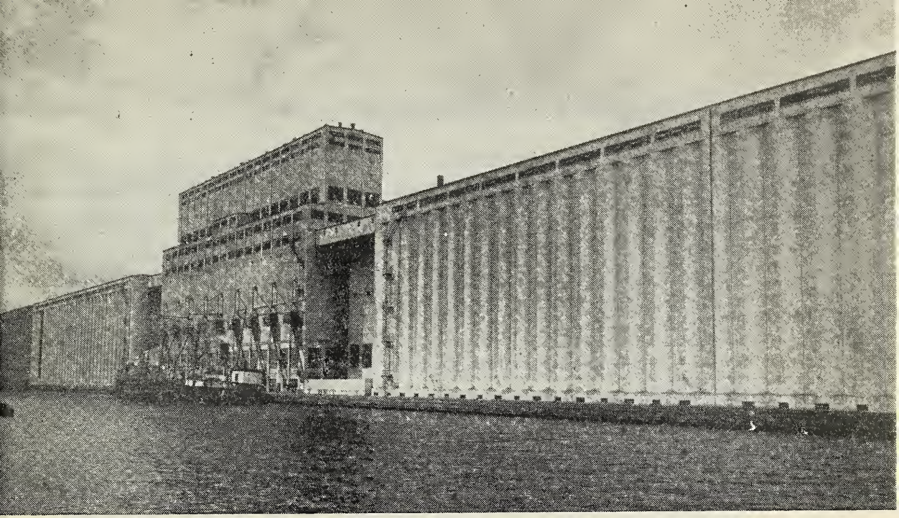

FIG. 249. Saskatchewan Pool Elevators Limited, Terminal No. 7 at the head of the Lakes; capacity, 9,000,000 bushels. (Photo from Saskatchewan Co-operative Producers Ltd.)

felt they were obliged to sell their grain, resulted in the organization of the Wheat Pools in 1924. Later, the Dominion Government established the Canadian Wheat Board to control the marketing of wheat.

When the Wheat Pools were organized it was believed that each pool would be in a position each fall to advance its members an initial payment with which to meet obligations, and at the same time to prevent the overloading of the market and a consequent disastrous drop in prices.

A wheat pool is an organization of farmers who pledge themselves to deliver all of their wheat to the organization, sell it co-operatively, and pool or distribute the net returns among themselves in proportion to the amount and quality of the wheat which each has contributed. Profits are returned to the members on the basis of the amount of wheat each has sold through the pool.

The advantages which may be derived from the operation of a wheat pool are as follows: The same price per bushel for the same grade of the same class of wheat is received by each member, irrespective of the time that he delivers his grain; this is the reason the organization is called a pool. The pool makes an initial pay-

ment when the grain is delivered, which enables the farmers to sell their grain in the fall and receive money with which to meet their financial obligations; the pool holds this grain in its elevators, places it upon the market gradually, and thus prevents the flooding of the market and a consequent drop in prices. As the wheat is sold, the pool makes further payments during the year until the full net value of the grain is paid. Because of its large membership, a pool is able, at a very small cost per member, to employ experts to direct its selling activities. A small charge (less than a cent per bushel) is made upon members for operating expenses; there is also a charge to cover the cost of purchasing or building elevators. Each member of a pool signs a contract to deliver all of his wheat to the pool for a period of years. The contract ensures the pool management of a large volume of wheat each year.

There is a co-operative grain marketing organization in each of the Prairie Provinces under the names of Alberta Wheat Pool, Manitoba Pool Elevators, and Saskatchewan Co-operative Producers Limited. They are all popularly called Wheat Pools.

During the early years of their operations, the three provincial pools marketed their wheat through a Central Selling Agency, known as the Canadian Co-operative Wheat Producers, Limited, located at Winnipeg. When later the Dominion Government placed the marketing of the Canadian wheat crop under the control of the Wheat Board, the selling activities of the Central Selling Agency were discontinued. None of the Wheat Pools now pool the sale of any grain. All three are operating as co-operative elevator companies. In doing so, they provide, through their local and terminal elevators, a service available to any farmer. They may, therefore, be described as service co-operatives.

The purpose of the Canadian Wheat Board, which was formed in 1935 by an Act of Parliament, was to provide for a voluntary Wheat Board and to put a floor under wheat prices in the Prairie Provinces.

Since 1943, the Board has been in the position of sole purchaser and seller of wheat delivered by farmers in Western Canada.

Both domestic millers and foreign buyers purchase from the Wheat Board. The Board uses existing export firms, including the Wheat Pools, to handle its export sales for it.

In 1946, the Government of Canada established a Five-year Pool to be administered by the Wheat Board. The Pool started with an initial payment of $1.35 per bushel. This price was later increased to $1.55 and finally to $1.75 per bushel. Each time the price was increased, the Board made additional payments to the producers who had delivered wheat to the Board at lower initial prices. This Pool expired in 1950 and as soon as all of the wheat involved could be disposed of a final payment was made. Provision was made in 1950 for the operation of Annual Pools. The policy of the Dominion Government has been directed towards achieving orderly and stable marketing of the wheat crop by international agreements that will assure not only equitable marketing arrangements at home and minimum prices for the protection of the producer, but orderly procedures in the world markets and a maximum price for the protection of the consumer.

In 1946, a United Kingdom-Canada wheat contract provided for the purchase by Britain of stated quantities of Canadian wheat each year. However, the contract was not renewed when it expired four years later.

The International Wheat Agreement. An International Wheat Agreement was negotiated in 1949 between five exporting countries, Canada, Australia, United States, France, and Uruguay, and forty-two importing countries in all parts of the world including the United Kingdom, Holland, Belgium, and other European countries, South Africa, New Zealand, China, India, Brazil, and Peru. Based on a guaranteed annual sale of 456,283,389 bushels of wheat for each of the four years of the agreement, the following prices were set: a maximum price of $1.80 for each year and a minimum price ranging from $1.50 in the first year to $1.20 in the fourth year. Each country agreed to buy or sell a definite amount of wheat annually. Canada's share was set at 203,069,635 bushels per year. Under certain conditions wheat flour may be

substituted for wheat. At a meeting in 1951 a substantial increase in Canadian deliveries during the following three years was agreed upon.

Exercise

The present powers of the Canadian Wheat Board expire in 1953 which is the terminal date of the International Wheat Agreement. Watch newspapers and other sources of information for announcements. Because of changing circumstances, teachers and students must be responsible for information regarding the present situation.

Other activities of the Wheat Pools. In 1944, the Saskatchewan Live Stock Producers, Limited amalgamated with the Wheat Pool. In Manitoba the Live Stock Marketing Co-operatives merged with the Manitoba Pool Elevators in 1948. The live stock co-operative organizations of the three Prairie Provinces own jointly the Canadian Live Stock Co-operative (Western) Limited, and maintain large public stockyards and marketing facilities at St. Boniface, Manitoba.

The Saskatchewan Wheat Pool programme (1951) includes the milling of flour and feed and the crushing of flax seed to produce linseed oil and oil cake. Manitoba Pool Elevators operates plants for processing live stock feeds and for preparing cereal and forage crop seeds.

The marketing of other farm products. It is not possible in this text to deal with the marketing of other farm products in the same detail as has been done in connection with wheat. The student must be responsible for keeping up-to-date with respect to international agreements having to do with bacon and other products. However, elsewhere in this text is considerable useful information regarding the marketing of beef cattle, pages 242 and 276; hogs, page 252; dairy products, page 290; milk, page 302; butter, page 307; cheese, page 309; wool, page 309; eggs and poultry, pages 337 and 339.

Canada's position in relation to world markets. Our wheat is sold in the markets of the world, Great Britain being one

of our best markets for bacon, dairy products, eggs, and cattle. In these markets we must face keen competition from other countries. Denmark is a strong competitor for the bacon market of Great Britain; it has the advantage of proximity to the British Isles. Our wheat, wool, mutton, and dairy products must compete with Australia and other countries which are located many miles from Britain, but which are able to ship their products by water, which is the cheapest means of transportation. The wheat and other farm produce of the prairies must be shipped many miles by railroad, which is much more expensive than water transportation.

Exercises and Problems

1. The importance of freight rates to the western farmer is well illustrated as follows: Freight from points on the eastern boundary of Saskatchewan to the head of the Lakes is 18 cents per 100 pounds of wheat. From the western boundary of the province the rate is 23 cents per 100 pounds. Calculate the difference in the freight charge between western and eastern parts of Saskatchewan on a 1700-bushel car of wheat being shipped to the head of the Lakes. (A bushel of wheat weighs 60 pounds.)

2. Explain how Canada can dispose of her agricultural products to the best advantage in the markets of the world in competition with other countries. In your answer discuss fully such questions as co-operation, high quality products, standardization, international agreements, etc.

3. What co-operative agricultural enterprises are active in your locality—an egg and poultry pool, carload shipments of live stock, etc.? Try to arrange for a member of one of these organizations to visit your school and discuss with you the advantages of co-operation.

4. Using information secured from newspapers and other available publications regarding the annual value of the products of Canada's farms, discuss the importance of agriculture in our economic life.

5. Watch newspapers and other publications for announcements of the activities of the Dominion Government in promoting the sale of Canadian agricultural products in other countries.

6. Arrange to visit a grain elevator; discuss with the grain buyer the marketing and grading of grain.

7. Make a collection of grades of Red Spring Wheat for your school.

CHAPTER 17

FARM AND HOME SURROUNDINGS

Planning the farm and the farm home. Time and money devoted to the planning and improvement of a farm are seldom wasted. Such an expenditure results not only in a feeling of satisfaction and pride on the part of the owner, but also in an increase in the value of the farm and a decrease in the cost of operating it.

The farmstead. The farmstead, which is the term applied to the grounds around the house, should be most carefully planned. Not only is it the business centre of the farm but it is also the home of the family. It should be made as attractive as possible. Trees and flowers should be used liberally and buildings should be painted frequently; a fresh coat of paint not only prolongs the life of a building but also considerably improves its appearance.

The farmstead should also be planned from the standpoint of convenience. Many miles of useless travel may be saved by grouping together such buildings as the horse barn, the implement shed, and the machine shop. The house should not be too far from the well. For the economical operation of the farm it is best to have the farmstead situated near the centre of the farm, but a location near a public highway has many advantages also.

The fields. As far as possible, the fields should be of equal size so that a satisfactory rotation of crops may be carried out. Long fields are more economical than square ones, as less time is wasted turning at the ends when ploughing or performing other operations. Which are more expensive to fence? The fields should be arranged so that each one may be reached quickly from the farmstead. Much valuable time is often used up in travelling long distances to and from the fields.

Exercises

1. A 4-acre plot in the shape of a rectangle measures 20 x 32 rods. A square plot the same size is 25 rods 5 feet along each side. (*a*)

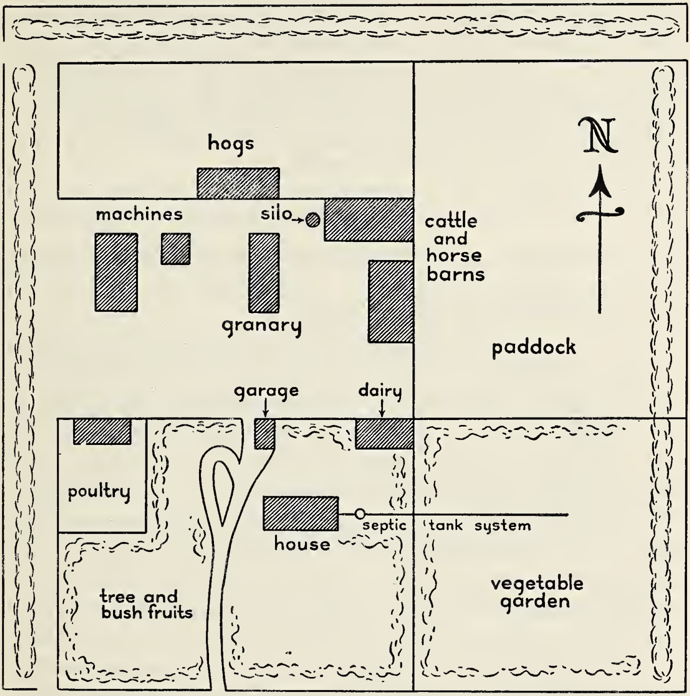

Fig. 250. A suggested plan for a farmstead, combining good appearance and utility. Each farmstead must be planned to suit the taste of the owner and the enterprise in which he plans to engage.

Calculate the length of fencing required for each field. (*b*) A two-bottom gang plough turns over a strip of soil 28 inches wide. At the end of each strip a turn must be made. How many more turns are required to plough the square plot than the long one? (*c*) If it takes, on the average, three-quarters of a minute to make each turn, how much more time is necessary to complete the ploughing of the square field than the long one?

2. A farmer is feeding a number of steers for a period of 300 days. They require 20 bushels of grain per day. The granary is situated 15 rods from the barn. A man can carry 2 bushels each trip, travel-

ling 3 miles per hour. (*a*) How many trips to the granary are required during the 300-day feeding period? (*b*) How many miles are travelled? (*c*) How much time is required? (*d*) What saving in time would be made by having the grain bin in the barn? (*e*) How much money would be saved at 20 cents per hour?

3. Draw a plan of your home farm. On the drawing, let 8 or 10 inches equal a mile. Locate all details.

4. Can you suggest any other arrangement of the fields or buildings that would reduce the time required to travel between them?

The farmhouse. The house should have the choicest position on the farmstead, preferably on high ground for dryness and near trees for appearance and shelter.

The house should be planned with care so that it will be comfortable, healthful, well lighted, and convenient. The size of the furniture should be taken into consideration when the plans are being made; and it is a good plan to arrange the doors and windows so that the furniture may be placed in any one of several positions. The windows in the bedrooms should be placed to prevent drafts across the beds. All windows should be a good size; small doors and windows are poor economy. A fireplace in the living room will prove a source of great comfort. As little space as possible should be used up in halls, as they are difficult to heat in cold weather. Plenty of clothes and linen closets should be provided.

The kitchen should be located on a corner of the house, where it will receive plenty of light. It should be designed for convenience. In the preparation and serving of meals, many steps may be saved by having the kitchen and dining room doors close together, and the sink, stove, cupboards, and work-table conveniently located. A washroom with an outside entrance off the kitchen or dining room will save a great deal of work.

The basement requires as careful planning as any other part of the house. The furnace should be located centrally not too far away from the chimney. Arrangements should be made for coal and wood bins, for fruit and vegetable storage, for a soft water cistern, a pneumatic tank, a lighting plant, and, if possible, for laundry space. A small gas engine in the basement, or in a

nearby out-house, can be used to pump water into the pneumatic tank, run the washing machine, turn the churn, operate the cream separator, and drive the lighting plant.

A pneumatic tank is cylindrical in shape and contains both air and water. When water is pumped in, the air is compressed in

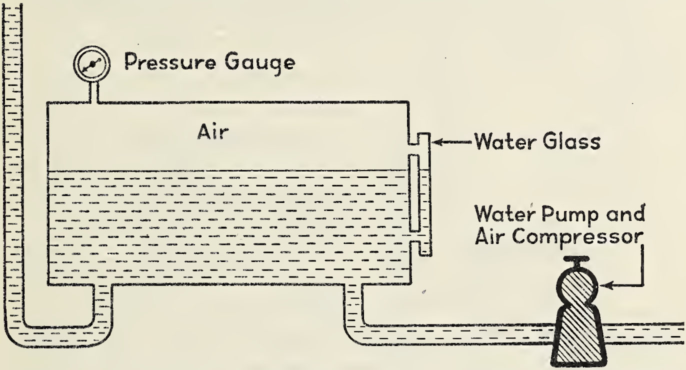

Fig. 251. A pneumatic tank, to raise water to the upper floors of the farmhouse.

the top of the tank. This compressed air exerts sufficient pressure upon the surface of the water to raise it to the upper floors of the house.

Where a water system is established and considerable water used, a septic tank is necessary to dispose of the sewage. A septic tank is made up of two compartments, in which gather certain forms of bacteria. In the first compartment the solid part of the sewage is reduced by the bacteria to a liquid. It then passes into the second compartment, from which it is discharged at intervals by an automatic valve or siphon into a series of tiles. Through the tile system it soaks away into the ground. As it finds its way through the tile and the soil, the water from the septic tank becomes purified. The tile and the tank should be buried deep enough to prevent freezing during the winter.

The well, from which the drinking water is drawn, should not be located below the tile system of the septic tank or where seep-

age from the barns may soak into it. A good supply of pure water is an essential to every farm.

Soft water from the roof should be stored in galvanized iron or cement tanks. If it is filtered before it enters the tank and the tank is kept tightly covered, the water will not as readily become

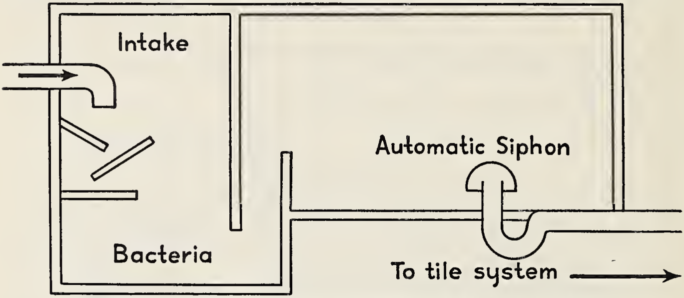

Fig. 252. A septic tank, for the disposal of sewage on the farm.

dark coloured or foul smelling. Even the flavour may be kept fresh in this way, if it is necessary to use this water for drinking purposes.

Exercise

What is being done in your province to provide electricity for farm homes and businesses? What are the advantages of having electricity on the farm?

The garden. Herbaceous perennial flowering plants. Herbaceous perennial flowering plants are plants with soft juicy stems, which die down to the ground each fall and grow up again from the root the following spring. When planted from seed, they do not usually produce flowers the first year; but, once established and given reasonable care, they produce a profusion of bloom annually. They are not difficult to grow and should have a place in every garden.

Herbaceous perennials require an open sandy loam that will not readily become hard or baked. The soil should be thoroughly prepared and enriched with well rotted manure before the plants are set out. A southern exposure, in full sunlight, and, if possible,

well protected from the wind, should be selected. Many perennials may be grown from seed started early indoors in shallow boxes, and transplanted into the garden when the danger of frost is over, usually about June 1st. Very satisfactory results are obtained by securing young plants or roots from reliable nurseries. Many perennials are propagated by root division. When this method is followed, planting is done in the late fall or early spring. Taller varieties should be placed at the back of borders or in the centre of beds. The area that will be occupied by the plants when mature should also be considered. Masses of the same colour produce the most attractive effect. An arrangement should be planned that will provide a continuous abundance of bloom throughout the entire growing season.

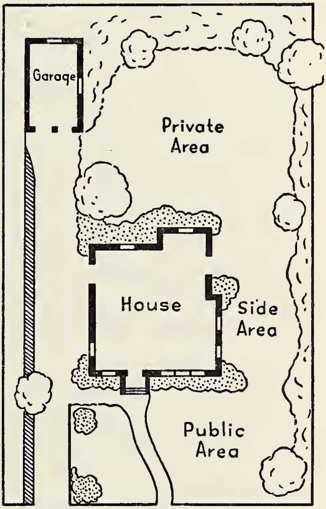

FIG. 253. A simple plan for the home grounds. Notice the three areas and the general arrangement of the trees, shrubs, and flower-beds.

During the summer the soil should be raked or hoed occasionally to control the weeds and conserve moisture. Blossoms, as they wither, should be removed. In the fall, after the ground is well frozen, the plants should be covered with about four inches of strawy manure or leaves. This blanket should be left on until the spring season of alternate thawing and freezing is over since this time of the year is even harder on the perennials than the winter. The coarse material should then be raked off, and the fine part thoroughly dug into the soil around the plants. Some of the hardy perennials are: columbines, larkspurs, pinks, bleeding hearts, iris, peonies, golden glow, spirea, Iceland poppies, delphinium, and sweet rocket. Bulbs,

such as tulips, are useful for early blooming, and may be followed later by geraniums or similar plants from the greenhouse.

Annual flowering plants. Many varieties of annual flowers are better started indoors and transplanted later into the garden. The seed should be planted in shallow boxes early in April. The soil used should be well enriched, thoroughly pulverized, and quite sandy. Why is a good supply of sand necessary? Most flower seeds are very small. They should be sprinkled on the surface of the soil and gently pressed with a board. A very thin covering of fine soil may be sprinkled over them; many failures with flowers are caused by covering the seeds too deeply. The boxes should be kept in the sunlight as much as possible to prevent the young plants from growing too quickly and becoming spindly. Transplanting into the garden should be done about June 1st. For more complete suggestions see also pages 130-134.

The soil in the garden should be deeply enriched with well rotted manure. It should be thoroughly raked to pulverize the lumps and to provide an even, level surface. Plenty of room should be allowed for each plant to develop.

There are varieties of annuals that may be started outside from seed. They should be sown early, usually during the first week of May. As mentioned above, the seeds should not be covered too deeply. As the plants grow, they may be thinned gradually until they are the desired distance apart. Annuals may be used to fill gaps in the perennial borders, or in beds by themselves. In regard to colour and size, the same general rules should be followed as were suggested in the case of perennials. Some easily grown and showy annuals are: poppies, asters, petunias, mignonette, nicotiana, verbenas, stocks, alyssum, calliopsis, pansies, and snapdragon.

Trees and shrubs for shelter belts and ornamental purposes.

The value of trees. In the Prairie Provinces there are too many houses and schools that have not a tree or a bush of any kind to relieve the harsh outline of the building or break the monotony of the prairie. Why should these conditions continue to exist?

Fig. 254. Contrast with the bareness of a treeless farm, this beautiful farm home, where trees transform the landscape and give shade, shelter, and protection the year round. (Photo from Dominion Forest Nursery Station, Indian Head, Saskatchewan)

Trees can be made to grow almost anywhere, if a little attention and care is given them. The expense is very small. The Dominion Forestry Branch has established Nursery Stations at Indian Head and Sutherland, Saskatchewan, and will supply broad leaf trees for wind-breaks, free of charge, to any farmer or school in the three Prairie Provinces. There is a small charge for evergreens. Transportation costs must also be paid. The Forestry Branch requires a thorough preparation of the soil in which the trees are to be planted and a guarantee that the trees will be well cared for after planting.

Note.—For information concerning tree planting or free distribution of trees, write to the Chief of Tree Planting Division, Dominion Forest Nursery Station, Indian Head, Saskatchewan.

Trees on a farm serve many purposes. They shelter buildings, gardens, crops, and live stock from the wind and hold back snow from the buildings during the winter; they supply moisture to the garden from melting snow in the spring; when planted in rows leading from the farm dugout and around it, they aid both in supplying water to the dugout and in reducing evaporation; they provide shade and make the home and its surroundings more attractive; they restore humus to the soil; they reduce soil drifting; they attract birds, which feed on harmful insects; and when they are no longer needed for other purposes, they provide fencing material or firewood. For all these reasons, trees greatly increase the value of the farm.

The location and arrangement of trees should be given very careful consideration because, once the trees are established, they

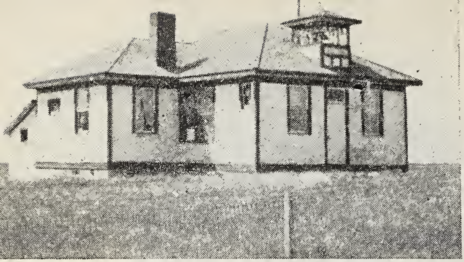

FIG. 255. This attractive rural school building on the open prairie will never be complete until the grounds are landscaped and planted to trees, shrubs, lawns and flowers. (Photo from Dominion Forest Nursery Station, Indian Head, Saskatchewan)

cannot readily be moved. Windbreaks should be heaviest on the sides of the farm most exposed to storms, usually the north and the west. Rows of trees should be placed at least thirty yards away from permanent buildings to prevent the drifting and piling of large quantities of snow around the buildings. The Forestry Branch will not supply trees for closer planting. Individual trees should be planted where they will appear to the best advantage.

Shelter belts should contain several rows of trees, the rows being placed four feet apart. In dry areas the main belt should not have more than three rows. Rapid growing trees should be spaced at intervals of four feet in the rows, and slower growing varieties more closely, at about three feet. If the wind-break is more than from five to eight yards wide, the trees are frequently broken down by the weight of the great volume of snow trapped. To prevent this, a single or a double row of trees is frequently planted about thirty yards out from the main belt to form a snow-trap to hold back some of the snow.

Preparation of the soil. The soil should be very thoroughly prepared before the trees are set out. It is essential to have the soil loose and porous, to destroy all weeds and grasses, especially the latter, and to conserve an abundant supply of moisture. Land under cultivation should be summerfallowed or used for intertilled crops for two years previous to the time of planting. New land should be broken early in the spring, backset later in the summer, and well cultivated for the remainder of the season, then thoroughly summerfallowed during the second year.

Planting may be done either before or after the growing season, while the trees are dormant, but only spring planting gives sure results. Small trees are more satisfactory than larger ones. Great care should be taken to prevent the roots of seedlings, especially

FIG. 256. View of extensive field shelter strips of trees at Conquest, Saskatchewan, where hundreds of miles of planted hedges criss-cross the countryside, which was at one time bare windswept prairie. (Photo from Dominion Forest Nursery Station, Indian Head, Saskatchewan)

evergreens, from drying out. They should be planted as soon as possible after being received from the nursery. If this cannot be done, a good plan is to *heel in* the seedlings. To do this, a trench is dug, the roots are placed in it, and the soil is thrown back to cover the roots and tops. The soil should be well worked in around the plants. When planting, the seedlings may be carried in a pail of thick, muddy water. All broken or injured roots of the larger trees should be trimmed off with a clean, sharp knife. Tops of deciduous trees should be pruned to balance the reduced root system. After the trees are in place, the soil should be thoroughly packed by tramping to press it around the roots and prevent it from drying out.

When large numbers of seedlings are being set out, a deep furrow may be opened by a plough. Care must be taken not to open the furrow too far ahead of the planter. Why? The planter should follow immediately in the wake of the plough, setting the trees in position; and some of the soil should then be thrown over the roots, and tramped. The soil may then be returned to the furrow by means of the plough and well packed around the seedlings. A sharp stick or dibble may be used to open the soil for cuttings, which are best planted in a slanting position and quite deep, with the buds pointing up.

In planting individual trees or shrubs, the hole should be made large enough to allow the roots to be well spread out. A part of the surface soil may be placed in the bottom of the hole, and the remainder used to pack around the roots. As the hole is

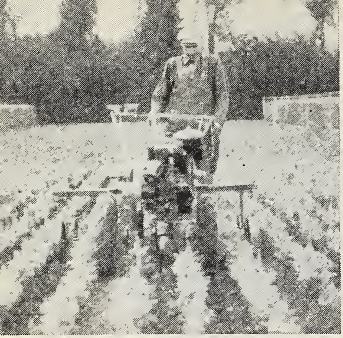

Fig. 257. Cultivating hundreds of thousands of young spruce and pine grown from seed on the Nursery Station and now ready to be lifted and transplanted in the spring to permanent locations on numerous prairie farms. (Photo from Dominion Forest Nursery Station, Indian Head, Saskatchewan)

being filled in, the soil may be thoroughly soaked with water. This assists in getting the soil well worked in between the roots, but, if the soil is watered, it should not be tramped. Tramping at this time would pack the soil into a hard mass, which would be very injurious to the growth of the roots. A small quantity of dry soil should be saved and spread over the moist soil to form a mulch.

Care after planting. To obtain the best results, trees should have a great deal of very careful attention. For three years at least, or until the trees are well established and large enough to prevent foreign growth by their shade, thorough cultivation should be carried on between the rows and for some distance out from the trees on both sides. Give two reasons for this. Wind-breaks should be carefully watched for the appearance of disease or insect pests, and, if necessary, steps should be taken immediately to control them. The Forestry Branch Nursery Stations at Indian Head or Sutherland will supply, free of charge, a bulletin dealing with the control of insects that attack shade trees. Branches that are broken by the wind or snow should be removed, and the wounds trimmed, if jagged, and treated to prevent the entrance of disease germs. It is essential that the trees should be fenced to protect them from live stock. Thinning is required to prevent overcrowding as the trees grow, but it has been found at the Indian Head Nursery Station that it is not necessary to prune or thin out trees in shelter belts until the belt is about eight to ten years old, and then only to protect ash and elms from quick growing varieties. The aim should be to keep the soil completely shaded.

Suitable varieties. Wind-breaks of mixed varieties usually give the best results since all trees are not subject to the same

disease or insect pests. Hardiness and resistance to drought are essential qualities. Some of the varieties used are: acute-leaf and laurel-leaf willows, which are quick growing and short-lived and are especially suitable for moist locations; Russian and north-west poplars; cottonwood, which is quick growing and short-lived and is not resistant to extreme drought; slower growing, more permanent, and drought-resistant kinds of trees such as Manitoba maple, American elm, green ash, American and Siberian larch; caragana, which requires a well drained soil; and such evergreens as white spruce, Scotch, jack, and lodgepole pines. The caragana is most strongly recommended for the outside rows, as it possesses several outstanding advantages over either the willows or the poplars for this purpose. It is not advisable to plant ash or elm between rows of willow, poplar, or Manitoba maple. The latter, fast growing trees, suppress and retard the growth of the slower varieties. Such native trees as the wild plum and the pin cherry usually give very satisfactory results when they can be obtained, and are well worth a place in the garden. Western-grown trees should be used whenever possible.

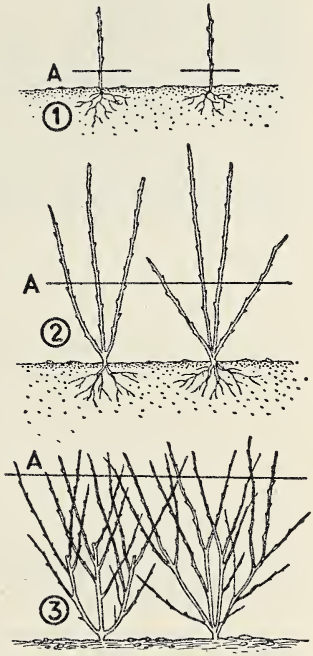

Fig. 258. Starting a caragana hedge. (1) One-year-old seedlings just planted, (one foot apart), should be cut off one inch from the ground at line A. (2) The following spring, six or eight inches of the previous season's growth should be cut back to line A. (3) The third spring, it should be trimmed back to line A before the leaves begin to grow. (Drawing from Dominion Forest Nursery Station, Indian Head, Saskatchewan)

Note.—Information about the best varieties of honeysuckles, lilacs, and other ornamental shrubs may be obtained from Indian Head, Sutherland, or the Experimental Station at Morden, Manitoba.

Hedges. The same care should be exercised in establishing a hedge as in setting out trees or shrubs for wind-breaks or ornamental purposes. Similar methods are used in planting it, and it requires the same attention later. The soil should be thoroughly prepared before the plants are set out. An effort should be made to train the hedge into a dense, compact row. This may be accomplished by careful pruning each year to cause the plants to branch more freely. Spruce and caragana are two of the most satisfactory hedge plants. The caragana is more commonly used. It may be started from one-year-old seedlings or from seed. The seed is planted, in the fall or very early in the spring, in rows about three-quarters of an inch deep with ten to twelve seeds per foot.

Projects

1. If a wind-break has not already been established around your school or around your home, make arrangements to plant one. Send to Indian Head or Sutherland for advice about your particular problems.
2. If grass and weeds have been allowed to grow up between the trees in the shelter belt around the school or around your home, organize a campaign to destroy these tree enemies, and put the wind-break in good condition again. Trees respond very readily to good care.

Lawns. The lawn that is not too much broken up with flower beds is the most attractive type. The soil should be well prepared and thoroughly enriched before the seed is sown. The surface of the ground should be made perfectly level. Care should be taken to have the seed-bed solid, so that no hollows will result later through uneven settling of the soil. Rolling the soil well at this time is a good practice. Seeding should be done as soon as the ground is well moistened with spring rains (the end of May or early June) or very late fall. The seed of many of the best grasses

FIG. 259. Superintendent's residence at the Dominion Forest Nursery Station, Indian Head, Saskatchewan. This site was originally bare prairie. (Photo from Dominion Forest Nursery Station, Indian Head, Saskatchewan)

is very small. For small lawns the seed is best sown broadcast over the surface of the soil, first lengthwise, then crosswise, and raked in with a fine toothed garden rake. After sowing and raking, the ground should be packed with a light roller to press the soil around the small seeds.

When fineness of grass is desired, a good seed mixture is thirty-five per cent Kentucky blue grass, thirty-five per cent Canadian blue grass, twenty-five per cent red top, and five per cent white Dutch clover. The clover is better sown separately. Chewing's Fescue is a useful lawn grass variety. When drought-resistance is a factor, the Fairway strain of crested wheat grass is good, although it does not make a closely knit lawn.

Where a coarser, better wearing lawn is required such hardy grasses as western rye or brome grass can be substituted for part of the Kentucky or Canadian blue grass.

Once established, the lawn must receive considerable attention to keep it at its best. It should be clipped frequently, and the cut grass removed. Every fall, a top dressing of well rotted manure should be applied. The coarse material should be removed in the spring, and the finer material carefully raked in around the roots of the grass plants. Special grass fertilizers may also be used. For this purpose pulverized sheep manure is very good. Fertilizers should be well raked in around the roots, and applied just before the lawn is watered or just before a rain. When spots in the lawn

become bare, the soil should be loosened with a rake and reseeded. A light coating of fine, loamy soil should then be applied and the surface rolled until it is firm.

Exercises and Problems

1. If you are not familiar with the perennial and annual flowering plants listed on pages 385 and 386, obtain an illustrated seed catalogue and find illustrations of them.

2. If possible, arrange a visit to an outstanding flower garden and tree plantation in your locality. Ask the owner to tell you about his plants and methods of cultivation. This very profitable and enjoyable activity has become an annual fall event in many schools.

3. Send for the bulletin entitled *Tree Planting on the Prairies of Manitoba, Saskatchewan, and Alberta,* which may be obtained free of charge from the Director of Forestry, Department of the Interior. Ottawa. This bulletin is well illustrated and contains a wealth of valuable information. A copy of it should be in every school library.

4. *Native Trees of Canada* (King's Printer, Ottawa; price $1.00) is also a valuable book on trees.

5. Draw a simple plan, to some convenient scale, showing the arrangement of a well planned farmstead. Your plan should show the arrangement of buildings, wind-break, snow-trap, gardens, lawns, and ornamental trees and shrubs. The bulletin *Tree Planting on the Prairies* has some very good plans and suggestions.

6. Discuss the value of trees, shrubs, lawns, and flowers in the establishment of a home on the farm or in the city.

7. Make a survey of your school yard. What suggestions can you offer to improve its appearance and general attractiveness? Put your suggestions in the form of a plan, drawn to a convenient scale.

8. What are the advantages of a well planned farmstead and home? Discuss this question from the standpoint of the owner, as well as from that of the people who will view the home and the grounds as they pass by.

CHAPTER 18

THE LIVING VALUES OF AGRICULTURE

The preceding chapters of this book have stressed the material and practical side of agriculture. But agriculture is more than a way of amassing wealth; it is more than a collection of information and techniques related to the production of crops and live stock. It can be a rich and satisfying way of life.

Unless you live in a centre that is highly industrialized, the prosperity of the merchants and other business men in your town or city is very closely linked with the prosperity of the farmers in the surrounding rural areas. Even in an industrial urban centre, the people are dependent upon the farmer for raw materials for the greater part of their food and clothing.

Agriculture is also, therefore, an important economic factor in the lives of all Canadians. Let us examine these two viewpoints more fully.

The importance of agriculture in the economy of Canada. Agriculture is one of the oldest occupations in the world. It has long been one of the chief sources of wealth and a vital factor in the prosperity of even those nations that have become highly industrialized. In Canada, agriculture is the leading primary industry. It is second only to manufacturing in the value of its products. In recent years, agricultural production in Canada has exceeded $1,500,000,000 annually.

Not only do more than one-quarter of the Canadian people engage in farming and depend directly upon agriculture for their livelihood, but on our farms are produced vast quantities of raw materials for many manufactures. Indirectly, therefore, agriculture provides a livelihood for many industrial and transportation workers. Between the prosperity of many urban centres and that

Fig. 260. An attractive farm home suggesting that there life is pleasant and satisfying. (Photo from Agricultural Representative Services, Saskatchewan Department of Agriculture)

of the surrounding rural areas there is a vital connection. It is not difficult to understand how good crops and satisfactory prices for farm products are reflected in the profits of the people who live in the centres in which the farming population spends its money.

As the producer of the world's food supplies, the farmer occupies an exceedingly important place. In Canada, as elsewhere, millions of people are dependent upon him for their food. With millions of fertile acres of land under cultivation, Canada is one of the largest producers of food for home consumption and for export. Millions of bushels of wheat and large quantities of other farm products are supplied annually to the food markets of the world.

Agricultural communities are important in another respect. There is, as there always has been, a constant flow of population from the farm to urban centres to swell the ranks of industrial and professional workers. That many of these people have in time become leaders in education, medicine, industry, scientific research, and other fields of activity, is due in part at least to qualities of character and mind developed during early life on the farm.

Agriculture is truly a basic industry.

Agriculture is a way of living. Many people have found their greatest source of satisfaction and happiness in the development of a farm as a home as well as a business. They have been proud of their broad acres of fertile soil and of their buildings and equipment, both of which they have maintained and im-

proved year after year. They have been proud of their good crops; their well fed live stock; their comfortable, well equipped homes; and their friends and neighbours who, like themselves, have pride in their farms and their community.

Many people prefer the country to the city as a place in which to establish their homes. Many farm homes are attractively situated in beautiful natural surroundings, and nowadays they can be made as pleasant, comfortable, and convenient as city homes. Rural health facilities have been greatly improved. Doctors and hospitals are more quickly within reach. Rural people can now enjoy many of the same cultural privileges as the city dweller: concerts, lectures, theatre, church, library. With all these advantages, the farmer and his family can work together as a team to build for themselves a happy, attractive home and a permanently prosperous business.

In many rural communities there are people who would not live elsewhere, because they find so much in rural life that satisfies them and gives them pleasure. Besides the satisfaction of an outdoor life they find many opportunities to engage in interesting and worth-while community activities and to give leadership in useful ways.

Over the years many changes have taken place in rural communities. Pioneer farming communities were forced to depend to a very large extent upon themselves. The people knew each other intimately. They co-operated in building each other's homes, their schools, and their churches. Their pleasures and entertainments were chiefly home-made. But modern methods of transportation and communication, such as the automobile and the radio, have reduced isolation and made other places much more accessible. As a result, people in some rural communities are going to larger centres for business, shopping, worship, and entertainment. Many rural communities, on the other hand, have remained united and have even strengthened their place in the lives of their people by the development of numerous community activities.

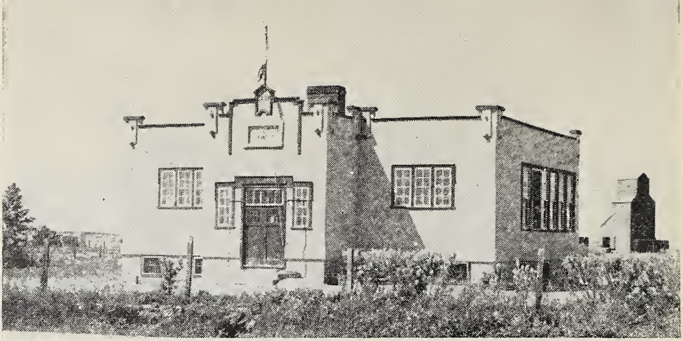

FIG. 261. Rural centres can provide for the people living in them and in the surrounding area, many opportunities to lead happy, useful lives. For example, in addition to its uses for educational purposes, the school can serve as the centre for many other community activities. (Photo from Saskatchewan Film Board)

The mechanization of farming operations has done much to remove hard manual labour and drudgery from farming, but it has also introduced new problems, particularly in the wheat-growing areas of the Prairie Provinces. Since fewer men are required, farm populations have declined. The result is increased difficulty in carrying on schools and other community activities. There seems to be no single solution for these problems. Each community must deal with them in its own way.

The school has always played an important part in community life, as the centre of many activities. To meet the growing needs of farming communities many rural schools are being improved. In some parts of the country small school districts are being consolidated, and one large school built to serve the needs of the whole area. A consolidated school can offer services that are not possible in the small one-teacher school. There is also a trend towards larger school units or districts, in which a number of schools are operated under the management of a central board of trustees. The larger units also make possible services that are beyond the ability of a single school district to provide. Many rural schools are lively community centres providing settings for a wide variety of community activities out of school hours.

Our agricultural resources must be conserved. The fertile soil of the farming areas of Canada is the basis of our agricultural

wealth. It is our most precious natural resource—the source of food and life. It is difficult to see how the people of any country can survive without good soil. Many countries have permitted methods of farming that have destroyed the soil. In Canada, our soil has been damaged in many areas, but there is still time to save it and to extend its usefulness.

Fig. 262. A Junior Baby Beef Club show. Activities of this nature do much to improve live stock and also to foster valuable community interests. (Photo from Agricultural Representative Services, Saskatchewan Department of Agriculture)

We hold the soil in trust, to use as we need it but as well to maintain its fertility for succeeding generations. The maintenance of the soil at a high level of productivity is the direct responsibility of the farmer. Rural areas must continue to provide financial security and satisfactory living standards for the people who operate the farms.

Aids to farmers. The Dominion and provincial Departments of Agriculture co-operate with the farmers in many ways. Problems of production and marketing are studied. Organizations, such as the Dominion Experimental Farms Branch, the Live Stock Inspection and Trading Service, the Prairie Farm Rehabilitation Administration (in the Prairie Provinces), Provincial Agricultural Representative Services, Cow Testing Associations, and others have been established to assist with and give direction to agricultural activities.

Farmers also have their own organizations: the Agricultural Institute of Canada, the Canadian Federation of Agriculture, and provincial bodies such as the Ontario Poultry Association, the Nova Scotia Fruit-Growers, and the Saskatchewan Co-operative Producers. These and other organizations like them are endeavouring to improve production and marketing procedures and to raise the quality of farm products to the benefit of both producer and consumer.

Fig. 263. Science is doing a very great deal not only to improve crops, live stock, tools, and machinery, but also to better conditions in rural areas. (Photo from Dominion Department of Agriculture)

The people in the farming communities of Canada have made an important contribution to our national life. In this chapter, we have seen how greatly the welfare of all depends upon the character and the work of the people on our farms. Surely, then, it is in the interests of all to see that rural life continues to attract large numbers of people and that agriculture is maintained on as sound and prosperous a basis as possible.

Exercises and Problems

1. Gather evidence for or against the statement that "agriculture is the basic industry in Canada." Be sure that your information is as complete and accurate as possible. Discuss your findings with others. What is your conclusion?

2. Select an urban centre and surrounding rural area. Show how each depends upon the other.

3. If you live in the country, make a study of your home community. What might be done to improve its contribution to the lives of the people in it?

4. Name several farmers' co-operative organizations. What are their aims? How have they contributed to the improvement of agriculture and rural life?

5. How have inventions, such as the radio, contributed to the improvement of farming and farm life?

6. Discuss the possible beneficial effects of irrigation and scientific farming upon the general stability of agriculture on the Prairies. How will a stable agriculture contribute to rural life and to urban prosperity?

APPENDIX

CALCULATING BALANCED RATIONS

The following outline elaborates the discussion of balanced rations, page 265.

The method of calculating a balanced ration for a cow. To balance a ration for a 1200-pound cow producing 30 pounds of 3.5 per cent milk per day, using prairie hay, corn silage, oat chop, and oil cake:

The first step is to determine the standard requirements for a cow of the foregoing description. From the standard (see page 402), it is found that a 1200-pound cow requires 0.762 pounds of digestible protein and 9.29 pounds of total digestible nutrients per day for maintenance. To these figures must be added the requirements for the milk produced. The standard allowance for each pound of 3.5 per cent milk is 0.046 pounds of digestible protein and 0.300 pounds of total digestible nutrients. For 30 pounds of milk the allowance would be $0.046 \times 30 = 1.380$ pounds of digestible protein and $0.300 \times 30 = 9.00$ pounds of total digestible nutrients. To determine the full daily allowance required, the allowance for maintenance and the allowance for milk production must be added together as follows:

	Digestible Protein	Total Digestible Nutrients
For maintenance	0.762 lb.	9.29 lb.
For milk produced	1.380 lb.	9.00 lb.
Total per day per cow	2.142 lb.	18.29 lb.

The second step is to make up a ration from the feeds given and determine whether or not it supplies protein, etc., within the limits of the standard. This calculation is made by the use of the table on page 261, in the same manner as the amounts of digestible protein and total digestible nutrients were determined in working out nutritive ratios, page 264. Starting with 10 pounds of prairie hay, 30 pounds of silage (see rule on page 265), 9 pounds of oat chop, and 1 pound of oil cake, calculate the total pounds of digestible protein and the total digestible nutrients contained in this trial ration. From the table on page 261 it is found that 100 pounds of prairie hay contain 2.6 pounds of protein—therefore 10 pounds will contain $\frac{2.6}{100} \times 10 = .26$ pounds.

	Dry Matter Lb.	Digestible Protein Lb.	Total Digestible Nutrients Lb.	Nutritive Ratio 1:
Dairy Cows				
A. For maintenance of 1000-lb. cow (per head daily)		0.650	7.930	
1200 lb. cow		0.762	9.290	
B. Add to maintenance allowance per pound of milk				
For 2.5% milk		0.040	0.251	
For 3.0% milk		0.043	0.276	
For 3.5% milk		0.046	0.300	
For 4.0% milk		0.049	0.324	
For 4.5% milk		0.052	0.349	
For 5.0% milk		0.056	0.373	
For 6.0% milk		0.062	0.422	
Calves Being Fattened for Baby Beef				
Weight 400 lb.	9.6-12.7	0.98-1.23	7.4-9.8	6.5-7.0
Weight 600 lb.	13.3-16.1	1.39-1.60	10.6-12.9	6.6-7.1
Weight 800 lb.	16.1-18.7	1.69-1.89	13.1-15.2	6.7-7.2
Weight 900 lb.	17.0-19.4	1.75-1.95	13.8-15.8	6.8-7.3
Horses (1500 lb.)				
Light Work	20.8-27.7	1.1-1.4	12.5-15.2	9.0-11.0
Medium Work	22.8-29.9	1.4-1.7	15.7-18.5	9.0-11.0
Hard Work	26.3-32.2	1.8-2.0	19.0-23.4	9.0-11.0
Fattening Lambs				
Weight 50 lb.	1.9-2.3	0.16-0.19	1.2-1.5	6.5-7.0
Weight 70 lb.	2.2-2.7	0.21-0.24	1.7-2.0	6.9-7.4
Weight 90 lb.	2.4-2.9	0.23-0.26	1.9-2.2	7.3-7.8
Weight 100 lb.	2.5-3.0	0.25-0.27	2.0-2.3	7.5-8.0
Growing and Fattening Pigs				
Weight 30 lb.	1.3-1.9	0.25-0.32	1.2-1.7	4.0-4.5
Weight 75 lb.	2.9-3.9	0.43-0.52	2.6-3.5	5.3-5.8
Weight 150 lb.	4.8-6.2	0.65-0.75	4.3-5.6	6.2-6.5
Weight 200 lb.	5.8-7.1	0.73-0.83	5.2-6.4	6.4-6.7

By the same procedure the total nutrients in the hay and the protein, and the total nutrients in the other feeds of the trial ration, may be calculated. Arrange your figures in a table thus:

First Trial Ration		Digestible Protein	Total Digestible Nutrients
Prairie hay,	10 lb.	.26 lb.	4.92 lb.
Silage,	30 lb.	.39 lb.	5.61 lb.
Oat chop,	9 lb.	.846 lb.	6.435 lb.
Oil cake,	1 lb.	.306 lb.	.782 lb.
Total		1.802 lb.	17.747 lb.
Morrison Standard		2.142 lb.	18.290 lb.

Placing the standard requirements after the total in each column, it will be seen at a glance that the foregoing ration is low both in digestible protein and in total digestible nutrients.

The third step is to make adjustments or additions to the trial ration in order to increase the constituents in which it is low. This can be done most easily, in many cases, by increasing the amount of oil cake used; but care must be exercised because of the cost of the oil cake. Increasing the oil cake to 2 pounds is suggested. The amounts of digestible protein and the total digestible nutrients of the second trial ration are calculated and arranged as before.

Second Trial Ration		Digestible Protein	Total Digestible Nutrients
Prairie hay,	10 lb.	.26 lb.	4.92 lb.
Silage,	30 lb.	.39 lb.	5.61 lb.
Oat chop,	9 lb.	.846 lb.	6.435 lb.
Oil cake,	2 lb.	.612 lb.	1.564 lb.
Total		2.108 lb.	18.529 lb.
Morrison Standard		2.142 lb.	18.290 lb.

The adjusted ration contains close to the right amount of digestible protein and just slightly more than the standard amount of total digestible nutrients set by the standard, and is, therefore, balanced. If the second trial ration had not balanced, a third trial ration would have been necessary.

Calculating balanced rations for other farm animals. The method followed in the case of other farm animals is identical with that outlined above for a dairy cow, with the exception that no allowance is required for milk production.

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